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The Great Basin Naturalist

VOLUME XXX, 1970

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A NEW *AMBRYSUS* FROM VENEZUELA (HEMIPTERA, NAUCORIDAE)

Ira La Rivers[1]

Subfamily Ambrysinae

Ambrysus scolius n. sp.

General: A rather small species measuring 8-9 mm. in length and 5 mm. in width; overall color various degrees of brownish mottling, from yellowish-to-blackish, head and pronotum distinctly mottled, hemelytra showing a darker and more uniform basic color. Venter varying from uniformly light yellowish-to-darker brownish, legs yellowish.

Head: Mottled yellowish laterally, darker brown medianly and posteriorly, eyes uniformly dark brown. Shiny, sparsely micropunctulate, comparatively flat. Anteclypeus (called "vertex" in many prior descriptions) slightly protuberant as a very weakly rounded outline between eyes. Eyes only slightly rising above general surface of head (seen obliquely from behind); posterior and lateral edges essentially forming a reasonably smooth and rounded semicircle with hardly a suggestion of angulation. Labrum not pointed at tip, but sharply rounded; ratio of length-to-width 8::12 (67%), color uniform. Mouthparts basally lighter in color than labrum. Head ratios are:

(1) Total length-to-width (including eyes) 35::48 (73%)
(2) Anterior distance between eyes to posterior distance between eyes 18::30 (60%)
(3) Anterior distance between eyes to inner eye length 18::25 (72%)
(4) Posterior distance between eyes to greatest length of head posterior to this line 30::10 (34%)

Ventrally, a sharp, brown-ridged median keel occupies posterior two-thirds of head and abutts against a similar pronotal keel; small, 3-segmented antennae tucked under ventral eye surface; color light yellowish.

[1]Verdi, Nevada 89439

Pronotum: Diffusely mottled brownish and yellowish; surface dull, smooth, grossly brown-spotted; lateral edges smooth, weakly and symmetrically curved back to postero-lateral angles which are between sub-posterior disc line and posterior pronotal edge. Percent of lateral-edge curvature about 10 (52::5). Venter light yellowish, a bit darker over coxal bases and showing an asymmetrical sigmoid subparallel edge with brownish spots; median area keeled anteriorly, sloping away sharply downward posteriorly to disappear under the anterior median region of propleura, which latter are not connected to median keel but free from it and only weakly joined at the middle; ratio of anterior keel ridge to total keel length (including posterior sloping face) 11::20 (55%). Pronotal ratios are:

(1) Width between anterior angles to width between posterior angles 48::95 (51%)
(2) Median length-to-greatest width 32::95 (34%)
(3) Distance between anterior and posterior angles on same side to perpendicular distance between anterior angle and baseline of pronotum 50::48.
(4) Distance between anterior angles-to-length of a perpendicular dropped from this line to the median anterior point of deepest penetration of head 50::15 (30%)

Scutellum: Not distinctive, very diffusely, vaguely and irregularly dark yellowish and dark brownish. Ratio of three sides, anterior and two laterals, 65::43::43.

Hemelytra: Brownish-black with some very diffuse and obscure yellowish lightening in emboliar region and behind median scutellar point. Embolia poorly defined posteriorly, this caudal edge apparent only from edge and a short distance inward; embolia slightly reddish, a bit lighter posteriorly, length-to-width 62::15 (24%), quite long and narrow; emboliar crease weakly developed anteriorly. Hemelytra moderately exposing connexival edges behind embolia and reaching tip of abdomen. Connexiva lighter than hemelytra, irregularly long-pilose and moderately spined at postero-lateral angles only on segments III, IV, and V.

Venter: The prothoracic venter has already been covered. Meso- and meta-thoracic ventra similarly bright yellow, less pilose than the plastron-covered abdomen. Posterior edge of Connexivum V is flared caudally in an asymmetric sigmoid curve, that of the left side more prominently than the one on right side. Female subgenital plate tip trisinuate in outline, the lateral sinuosities in the form of distinct but short points, the central one a long, smoothly rounded curve extending farther cauded than the lateral points (and in some specimens itself being distinctly weak-angulate medianly). No males are yet known, so we have no concept of the shape of the male subgenital flap on posterior edge of fifth abdominal sternite.

Legs: *Prolegs*—large angular coxa and trochanter usual for the genus, light yellowish. Femur strongly incrassate, ratio of length-

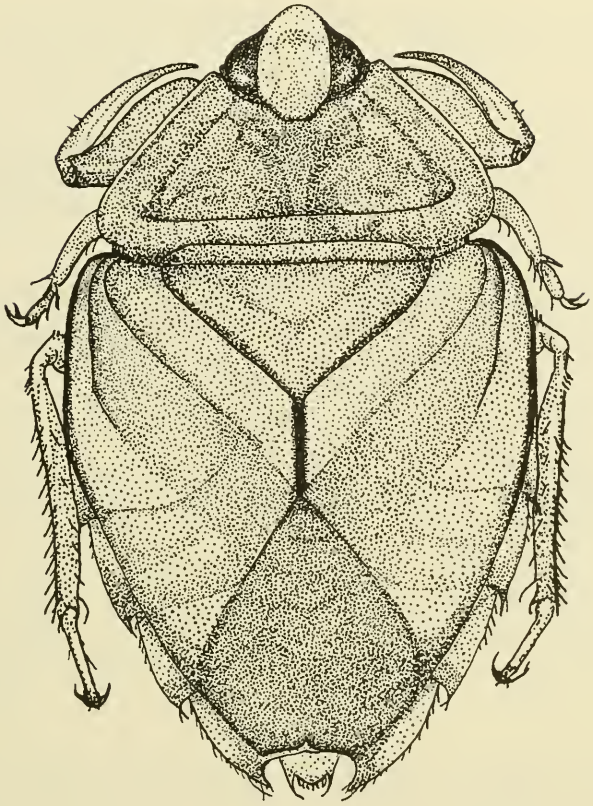

Fig. 1. *Ambrysus scolius*, holotype

to-greatest width 45::30 (67%). Tibia usual, combined tibia-tarsus just reaching end of femur when closed.

Mesolegs—Coxa and trochanter usual. Femoral ratio of length-to-width 53::7 (13%), length 2.1 mm. Tibia narrower, conspicuously but sparsely red-spined along margins, distal end ventrally with a terminal transverse, dense row of small brown spines and an incipient transverse row showing just behind it; ratio of length-to-width 44::4 (9%), length 1.9 mm. Tarsus long, thin, 3-segmented, first segment short, last segment terminating in two slightly curved claws.

Metalegs—Coxa and trochanter usual. Femoral ratio of length-to-width 56::8 (14%), length 2.5 mm. Tibia long and slim, more square in cross section, conspicuously but sparsely set with long reddish spines and showing a prominent swimming pelt along hind margin; terminal spination as in mesotibia except that the subterminal transverse spination is better developed and more row-like; ratio

of length-to-width 70::4 (6♂), length 3.0 mm. Tarsus similar to mesotarsus, but larger.

Type Localities and Etymology: Holotype female, Venezuela, *Monagas*, 42 kilometers SE Maturin, 1958 July 3, A. Menke; 1 female paratype, British Guiana, *Honey Camp Cr.*, 1937 October 24, S. Harris; 1 female paratype, British *West* indies, *Trinidad*, Port of Spain, 1931 November 5, W. E. Broadway. "Scolius", *curved*, *bent*, *oblique*, alluding to the flared hind margin of Connexivum V, particularly on the left side.

Comparative Notes: Superficially much like *A. oblongulus* Montandon 1897, of which group it is a member, differing in the outline of the female subgenital plate tip (trisinuate in *A. scolius*, quadrisinuate in *A. oblongulus*) and in the fact that *A. scolius* has only one-and-a-fraction transverse rows of terminal spines at distal end of metatibia while *A. oblongulus* has two-and-a-fraction such rows. Also, *A. oblongulus* lacks the sigmoid flare of the posterior margin of Connexivum V from which *A. scolius* derives its name. Discovery of the male of *A. scolius* will probably show differences in the subgenital flaps as well.

A NEW SPECIES OF ORIBATID MITE (CRYPTOSTIGMATA: ORIBATELLIDAE)

William B. Grabowski[1]

The genus *Oribatella* Banks, 1895, contains 22 species, many of which were poorly described in the light of modern systematic standards. In reviewing the Oribatellidae (Grabowski, 1967), I found that little attention was given to such characteristics as chaetotaxy of the legs, dorsal and ventral hysterosomal setation, morphology of the gnathosoma, arrangement of genital setae, and presence and placement of porose areas. Such details are included in this description.

Oribatella anomola n. sp.

(Figures 1-5)

Diagnosis

This representative differs from other species of *Oribatella* in the peculiar morphology of the lateral and ventral setae on the genu, tibia, and tarsus of legs one and two, and the iteral and proral setae on tarsus one. All of these setae are enlarged, barbed, and spindle shaped. The laterals of the genu and tibia are the most striking in this aspect and are readily evidenced under low power of the microscope. I have assigned the name *anomola*, meaning strange or different.

Description

Lamellae deeply bifid. lamellar cleft U-shaped to block U-shaped, lateral dentes with two to four notches on anterolateral borders, lateral areas of lamellar cusps, finely ridged, mesial dentes lying close together for two-thirds their length distally, then separating to form the cleft (Figure 1); lamellar hairs long, barbed, interlamellar hairs reaching to tips of lamellar hairs, thinner by comparison, barbed, and inserting laterad, close to dorsosejugal suture; pseudostigmatic organ elongate, clavate, finely barbed distally for two-thirds its length.

Hysterosoma approximately as broad as long, pteromorphs shallowly decurved, their entire surface finely wrinkled; eight pairs of smooth, medium length setae arranged as given in Figure 1; three pairs of porose areas, each occuring on a slight elevation; A_a located near setae D_a within a triangle formed by scapular seta C_2 and notogastral setae D_a and L_a, A_1 equidistant between setae D_m and L_m, A_2 equidistant between L_m and L_p (Figure 1).

Camerstome oval, rutella diarthric, one pair of short, finely barbed posterior infracapitular (mental) setae, one pair of median in-

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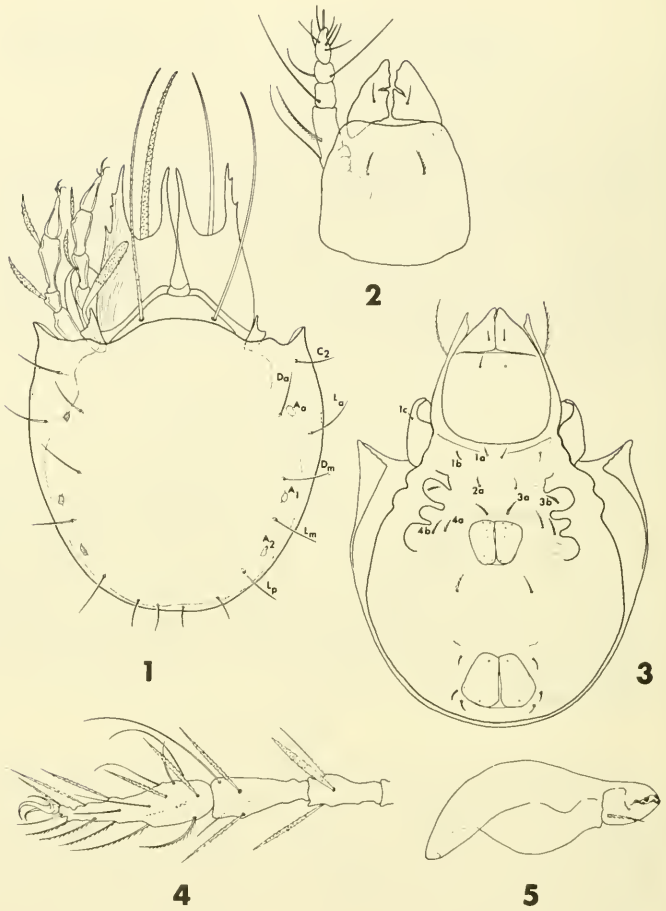

Figure 1. Dorsal view, *Oribatella anomola n. sp.*, legs one and two, right side, shown, illustrating modified setae.
Figure 2. Infracapitulum, pedipalps, and rutellum, ventral view, *O. anomola.*
Figure 3. Ventral view, legs omitted.
Figure 4. Genu, tibia, tarsus, leg one, greatly enlarged.
Figure 5. Chelicera, lateral view.

fracapitular (rutellar) setae, entire surface of infracapitulum finely punctuate; setation of pedipalp segments as given in Figures 2, 3; chelicerae chelate (Figure 5).

Ventral surface finely punctate, coxisternal setae 3a-b, and 4a-b finely barbed, 1a-c and 2a smooth, 3c and 4c absent from all specimens examined; genital plate with six pairs of setae: g_1 and g_2 on anterior edge of each cover, g_3, g_4, and g_5 in a line oriented mesially and running parallel to opening, g_6 in posterior median corner of

plate, one pair of short, barbed aggenital setae posterior and lateral to genital plate; anal plate with two pairs of setae, fissure "iad" present anterolaterally to each cover of anal plate, three pairs of short, barbed adanal setae lateral and posterior to plate.

Lateral setae on genu and tibia of legs one and two enlarged, spindle-shaped, distinctly barbed, laterals on tarsus one smaller by comparison, but of same morphology, iteral and proral setae also similar in morphology but more elongate and thin, no tectal setae, two whip-like solenidia, famulus elongate, pointed, unguinal, subunguinal, and subtarsal setae elongate, barbed on ventral aspect (Figures 1, 4).

Color, dark brown; total length, 445 μ; length propodosoma, 150 μ, width propodosoma, 145 μ, length hysterosoma, 305 μ width hysterosoma, 325 μ. 15 Specimens examined; eight taken from leaf little (unidentified) near Legion Lake, and seven from moss (unidentified) mixed with duff, near Nordbeck Game Preserve, Custer State Park, South Dakota, 27 and 28 August, 1968, by T. A. Woolley.

Discussion

This representative is unique owing to the peculiar morphology of certain of the leg setae described above. The absence of coxisternal setae 3c and 4c is difficult to explain and the dorsal setal nomenclature must remain provisional. Little information is available concerning developmental stages of these features. However, the pattern of dorsal setation demonstrated here appears standard for most species of *Oribatella*, although previous workers have reported from eight to eleven pairs of dorsal, notogastral (hysterosoma) setae (Grabowski, 1967).

Notching of the lateral dentes in *Oribatella* is a rather common occurence and has been reported in the following: *O. angulosa* Csiszar, 1962, *O. berlesei* Tuxen, 1945. *O. brevicornuta* Jacot, 1934, *O. brevicuspidata* Hammer, 1961, *O. dentaticuspis* Ewing, 1909, *O. dudichi* Willman, 1937, *O. illuminata* Hammer, 1961, *O. meridionalis* Berlese, 1908, *O. prolongata* Hammer, 1961. *O. puertomonttensis* Hammer, 1962,*O. quadrispinata* Hammer, 1962, *O. reticulatoides* Hammer, 1955, and *O. tenius* Csiszar, 1962. The new species described here appears closely related to either *O. brevicornuta* or *O. meridionalis*. This judgment is based on similarities of the lamellae, lamellar cleft, lamellar hairs, pseudostigmatic organ, and arrangment of the genital setae.

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NOTES ON THE HERPETOLOGY OF GRANT COUNTY, OREGON

Jeffrey Howard Black[1] and Robert M. Storm[2]

Grant County, located in eastern Oregon, occupies an area of 4,533 square miles and is bordered by Morrow, Umatilla, Union, Baker, Malheur, Harney, Crook and Wheeler Counties. The herpetology of Grant County is little known, which is indicated by the fact that many of the species are here recorded for the first time from the county.

The present account concerns collections made in the summers of 1964 and 1965 and records in the Natural History Museum at Oregon State University. Most of the specimens upon which this paper is based are deposited in the Natural History Museum, Oregon State University, Corvallis. We wish to thank the people of the Grant County for their help and hospitality.

Amphibia

1. *Ambystoma macrodactylum.* Long-toed salamander larvae were collected in the Murderers Creek drainage throughout the summer of 1964. Three larvae were observed in a small cold spring at 5,000 feet of elevation from 26 June 1954, until 3 August 1964; no change in size was noted. Metamorphosis in permanent water probably takes two years at this elevation. Larvae were also found in temporary pools filled with snow and rain runoff. Very small larvae were noted in a turbid temporary pool on Umatilla Creek 11 July 1964, and a return visit on 21 July 1964, found the pool dry and only one small juvenile under a piece of bark. Adult salamanders have been collected throughout the John Day Valley in moist habitats such as under rotten logs and in water reservoirs. *Hyla regilla* adults and tadpoles were usually found associated with *A. macrodactylum* in the early spring. Localities: Cold Spring, Murderers Creek Guard Station spring, Riley Creek Meadows, Bates, Dayville, and Umatilla Creek.

2. *Bufo boreas.* Tadpoles were collected from 29 June 1964, until 2 August 1964, in the Murderers Creek drainage. Tadpoles of *Hyla regilla* and *B. boreas* were in the same pools. Adults were collected from 1,800 to 7,000 feet of elevation. Localities: Lake Creek Guard Station, Wickiup Creek, Johnny Kirk Spring, Bates, Cant Ranch, Murderers Creek Guard Station, Riley Creek Meadows, Miners Creek, Stewart Reservoir, and Big Cabbage Patch Spring.

3. *Hyla regilla.* On 12 June 1965, hundreds of tree frog tadpoles in various stages of metamorphosis were found in a small pool

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of turbid water in the dry John Day Fossil Beds. On 23 June 1965, an adult male was collected in a squirrel hole in the middle of a dirt road on Antelope Flat. Other adults were collected in cracks of rotten logs, under logs, in ponderosa pine thickets, springs, swamps and other moist habitats. Localities: Middle Fork John Day River, Blue Mtn. Hot Springs, John Day Fossil Beds, Antelope Flat, Hines Work Road, Antelope Creek, Umatilla Creek, Big Weasel Spring, Big Cabbage Patch Spring, Stewart Reservoir, Canyon City, and Dayville.

4. *Rana pretiosa.* Representatives of this species are common in Grant County. It occupies springs, streams, lakes and marshy areas. Localities: Sugar Spring, Antelope Flat, Canyon Creek, Antelope Creek, Stewart Reservoir, Middle Fork John Day River, Blue Mtn. Hot Springs, High Lake, Lake Creek Guard Station, and South Fork John Day River.

5. *Rana catesbeiana.* The bullfrog was introduced into the John Day River Valley in 1923 by Irving Hazeltine, district game warden for Malheur, Grant, Harney and Baker Counties. Hazeltine received permission from the Oregon State Game Commission to ship frogs into the area. The bullfrogs were obtained from the Boise Valley in Idaho where they had been introduced from Alabama. The first delivery was made to Si J. Bingham, supervisor of Malheur National Forest, who was directed to liberate the bullfrogs in a pond on the Dale Ranch a few miles from Canyon City. Bullfrogs were also distributed along the John Day River in Grant County, to Harney and Baker Counties, and into California. Present habitat includes permanent ponds along the John Day River, irrigation ditches and other permanent water. Localities: Observation records show that the bullfrog is found in suitable habitats throughout the county.

Reptilia

6. *Clemmys marmorata.* A male western pond turtle was collected by Mrs. Howard Newton in May, 1965, along Canyon Creek. Turtles have been sighted in ponds bordering the John Day River. It appears western pond turtles are becoming established, but are still limited in numbers. Localities: Canyon Creek.

7. *Sceloporus occidentalis.* The western fence lizard was collected sunning on rocks and under sagebrush on hillsides of the Picture Gorge and John Day Fossil Beds. Localities: Picture Gorge, Cant Ranch, and Sheep Rock.

8. *Uta stansburiana.* The side-blotched lizard is common in the rocky gullies and open sagebrush areas of the John Day Fossil Beds. Localities: John Day Fossil Beds, Monroe Fossil Beds, and Picture Gorge.

9. *Eumeces skiltonianus.* The western skink was found at 4,600 feet of elevation in the ponderosa pine of Oregon Mine Creek and on

the rocky sagebrush-covered hillsides of the John Day Valley. Localities: Picture Gorge, Canyon City, Oregon Mine Creek, and Dayville.

10. *Charina bottae.* Seven rubber boas were collected in Grant County during the summer of 1964. On 12 June 1964, an adult was found under a 5 gallon milk can along Canyon Creek. Golden-brown juveniles were collected on Tennessee Creek and Todd Creek on 29 August 1964, and 10 September 1964. Wayne Stewart collected a large female on the Stewart Ranch on 15 September 1964. On 16 September 1964, this female gave birth to three young. The young were golden dorsally and pink ventrally. An adult male *Peromyscus maniculatus* was confined with the adult and the young on 17 September 1964. At 11 P.M. noise was heard in the cage where one of the young had wrapped itself around the mouse's neck. The tail was always in an unprotected position waving in front of the mouse, while the head was well-protected behind several coils around the neck. The battle continued until the tip of the snake's tail was bitten off. Adult rubber boas were found to readily eat young *Microtus sp.* Localities: Canyon Creek, Tennessee Creek, Aldrich Mountain, Wayne Stewart Ranch, and Cottonwood Creek.

11. *Coluber constrictor.* On 24 July 1965, a large racer was found coiled around a water pipe in a spring box on the Cant Ranch near Dayville. Part of its coils were under water. It was reported that this spring box usually contained many *H. regilla*, but at this time only two frogs could be found. The racer is common at lower elevations in Grant County. Localities: John Day, Cant Ranch, Birch Creek, Fields Creek, and South Fork John Day River.

12. *Pituophis melanoleucus.* This snake is common in the rimrocks and alfalfa fields at lower elevations. Localities: Canyon Creek, Cant Ranch, Kimberly, and Dayville.

13. *Thamnophis sirtalis fitchi.* Members of this subspecies have been found with *T. e. vagrans* around temporary ponds in the Murderers Creek area where young *H. regilla* and *B. boreas* were numerous. *T. s. fitchi* seems more restricted to aquatic habitats than does *T. e. vagrans.* Localities: John Day, Seneca, Antelope Creek, Murderers Creek Guard Station, Middle Fork John Day River, and Blue Mtn. Hot Springs.

14. *Thamnophis elegans vagrans.* The wandering garter snake was usually found near water. Two large adults were collected along Murderers Creek on 20 July 1964. One contained three naked young of *Peromyscus maniculatus*, the other regurgitated a six inch rainbow trout. Localities: Bates, Page Ranch, Antelope Flat, Hines Work Road, Canyon City, Murderers Creek, Charlie Mack Creek, southeast of Izee, and south of Seneca.

15. *Crotalus viridis.* Members of the subspecies *C. v. oreganus* are common in Grant County, but one specimen from near Izee appears to be the subspecies *C. v. lutosus.* Coloration in *C. v. oreganus*

varies from light gray in sagebrush areas to dark green at higher elevations. Most are found in the dry foothills surrounding irrigated valleys. Localities: Ritter. John Day, Murderers Creek Ranch, Cant Ranch, Fields Creek, and Shaw Spring.

Phrynosoma platyrhinos was not collected from the county, but locality records in the John Day country are reported by Gordon (1939). The following reptiles and amphibians have been reported from adjacent areas and may occur in Grant County; *Ascaphus truei Scaphiopus hammondi*, *Sceloporus graciosus*, *Cnemidophorus tigris*, *Masticophis taeniatus* and *Hypsiglena torquata.*

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A FOSSIL TURTLE FROM THE GREEN RIVER FORMATION IN UTAH

Kenneth Larsen[1]

In November, 1967, I found a fossil turtle in the talus of a 100 ft cliff whose base is 800 ft above the bottom of the Green River Formation. The cliff is 10.7 mi east of Thistle Junction on U.S. highway 50, Utah County, Utah. The fossil consists of the greater part of the carapace and plastron. The carapace is 240 mm long and 188 mm wide (fig. 1-A). The plastron is 200 mm long and 84 mm wide at the center of the bridge (fig. 1-B). This specimen is now in the Brigham Young University Earth Sciences Museum (No. BYU-R250).

The turtle belongs to the family Emydidae and keys to *Echmatemys ocyrrhoe* following the key of Hay (1908: 287, 298). He listed records for this genus from the Wasatch Formation of New Mexico, and the Bridger and Uintah Formations of Wyoming, however, it most closely resembles the illustrations of *E. stevensoniana* Leidy, 1870.

In order to determine the correct placement of the fossil, its measurements were compared with those of the closely related species *E. lativertebralis*, *E. aegle*, *E. cyane*, *E. ocyrrhoe*, *E. shaughnessiana*, and *E. stevensoniana*. The length and width ratios of the neural plates and vertebral scutes were computed to determine significant differences (Table 1). The degree of relationship between any two forms was taken as the average of the degrees of relationship for each measurement. This relationship ("R") was calculated with the formula $R = 1 - \left|\frac{a-b}{a+b}\right|$ where "a" and "b" are the same measurement in the two forms. The average "R"s between the different forms (Table 2) relate the new fossil more closely with *E. stevensoniana* (R=.9582) than with other species. Inasmuch as other pairs are more similar—*E. ocyrrhoe* and *E. aegle*=.9611, and *E. shaughnessiana* and *E. stevensoniana*=.9624 it is reasonable to assune that the recent find is a new species. On this basis and relative to the data in Table 1 some of Hay's species may be synonyms. I suggest three groupings: (1) *E. lativertebralis;* (2) *E. aegle*, *E. cyane*, and *E. ocyrrhoe;* (3) *E. shaughnessiana*, *E. stevensoniana*, and the recently discovered fossil from Utah.

The similarities between the Utah fossil turtle and *E. stevensoniana* support the hypothesis that the base of the Green River in central Utah correlates with the Bridger formation of Wyoming, but the Green River of Wyoming is actually older. However, one spe-

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Table 1. Length to width ratios of neural plates and vertebral scutes of several species of *Echmatemys*.

Species	Neural plates							Vertebral scutes		
	2	3	4	5	6	7	8	2	3	4
E. lativertebralis	.78	.88	.72	.68	.49	.35	.59	.89	.97	.75
E. ocyrrhoe	1.04	1.15	1.12	1.32	.75	.69	.73	.94	1.15	1.14
E. stevensoniana	1.28	1.43	1.43	1.07	.85	.79	.87	1.14	1.28	.91
E. aegle	1.11	1.21	1.11	1.11	.69	....*	....	.89	1.03	....
E. shaughnessiana	1.12	1.46	1.33	1.10	.75	1.39	.71	1.03	1.22	1.15
E. cyane	1.18	1.25	1.12	.97	.73	....	....	1.33	1.22	....
Echmatemys sp. nov.?	1.28	1.33	1.25	1.20	.97	.79	.87	1.18	1.16	1.35

Table 2. Average relationship (R) between species according to the formula $R = 1 - \frac{|a - b|}{|a + b|}$

	E. sp. nov.?	*E. stevensoniana*	*E. shaughnessiana*	*E. cyane*	*E. aegle*	2 *E. ocyrrhoe*
E. stevensoniana	.9582					
E. shaughnessiana	.9421	.9624				
E. cyane	.9343	.9344	.9438			
E. aegle	.9162	.9092	.9436	.9382		
E. ocyrrhoe	.9247	.9068	.9413	.9319	.9611	
E. lativertebralis	.7783	.7764	.8058	.8167	.8592	.8379

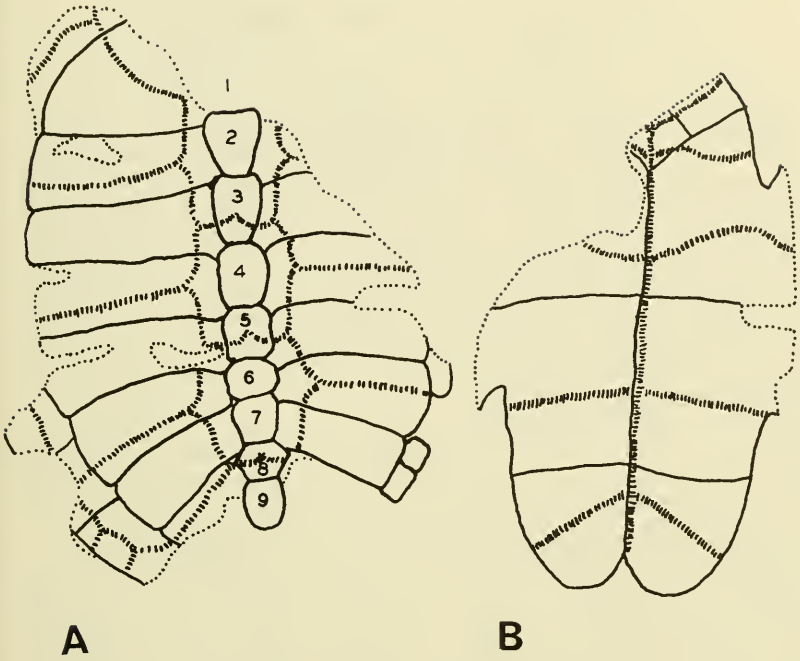

Figure 1: A. Carapace: B. Plastron

cimen is not sufficient and more work with the vertebrate fauna of the Green River Formation in central Utah is necessary before conclusive correlations can be made.

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NEW AND UNUSUAL PLANTS FROM UTAH

Stanley L. Welsh[1]

The flora of Utah has been under investigation for the past century. It is not surprising, however, that new or unusual entities are found from time to time, even after the state has been botanized by many interested persons. The state is huge, has a rugged topography, and a varied climate. And, there has never been a sufficient number of botanists with time enough to devote to botanical exploration of Utah. In recent years, the number of students of Utah botany has increased, and with each passing year new taxa are being discovered. During the past two decades numerous new entities have been described from the state, and range extensions are so numerous that they are seldom published.

Thus, as exploration continues and as more investigators search the poorly explored sections, more entities will be added to the large list of plant species already known. The present paper adds three taxa to the state flora, one previously known from a collection on the San Rafael Swell, and the other two previously undescribed.

The dogbane family (Apocynaceae) is represented in Utah by the genera *Apocynum* and *Amsonia*. The species in each of those genera are easily distinguished in the field. Thus, I was surprised when, in early May of 1968, I happened upon a clump of plants which were obviously apocynaceous, but which did not belong to either *Apocynum* or *Amsonia*. The clump of plants was about four feet square, and was situated on a bank of a badly eroded intermittent stream channel in Castle Valley on the west side of the La Sal Mountains, Grand Co., Utah. The plants were bright green and in early flower. I searched for other clumps of the plant, but was unsuccessful. In late May of 1968, Dr. Glen Moore and I returned to the site and collected some plants in full flower. The two of us conducted a thorough search of the vicinity but failed to find additional specimens. The clump was visited again in September of 1969 and still survives on its precarious perch.

The plant has been identified as *Cycladenia humilis* Benth. var. *venusta* (Eastw.) Woodson ex Munz. The species is known from California only, and the variety from Monterey and Los Angeles Counties, California, and from the San Rafael Swell, Utah (Abrams, 1951). The basis for the report from the San Rafael Swell is not known by me. Presumably, the plant was collected in the San Rafael Swell by M. E. Jones, possibly in 1914 or 1915. He visited that region on both of those years. However, he was also in Castle Valley during 1915 (Munz, 1965).

Voucher specimens for *Cycladenia humilis* in Utah (Figure 1, Map 4): Grand Co.; Castle Valley, ca. 4.5 miles east of junction

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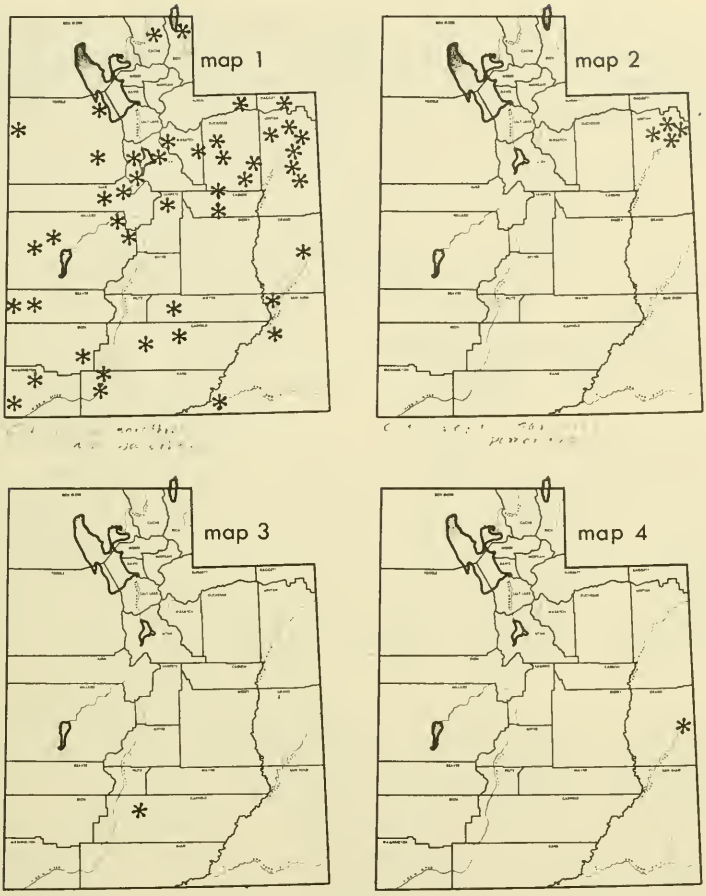

Map 1. Distribution of *Gutierrezia sarothrae* var. *sarothrae* based on specimens in the herbarium of Brigham Young University.
Map 2. Distribution of *Gutierrezia sarothrae* var. *pomariensis*.
Map 3. Distribution of *Eriogonum revealianum*.
Map 4. Distribution of *Cycladenia humilis* var. *venusta*.

with Utah highway 128, S. L. Welsh 7013, 3 May 1968 (BRY); do S. L. Welsh and G. Moore 7168, 29 May 1968 (BRY).

Eriogonum revealianum, n. sp.

A *Eriogonum corymbosi* differt pedunculis longior et caulibus foliaceis basi tantum.

Fruticulus 1.5-3 dm altus, erectus; caules basi per 3-10 cm foliosi; laminae foliorum lanceolatae, 1.5-3 (3.5) cm longae, (0.3) 0.5-1.4 cm latae, albo-tomentosi supra et infra, petiolis 0.7-2 cm longis; cau-

les tomentosi dense, 3-10 dm longi; pedunculi 6-13 cm longi, tomentosi; bracteae minutae ad foliiformes; inflorescentiae cymarum, ramus principalibus 2-4 (5). 1.5-6 cm longis; involucra turbinata, 2.5-4 mm longa. 2-2.5 mm lata. sessilia vel subsessilia; perianthia

Fig. 1. *Cycladenia humilis* Benth. var. *venusta* (Eastw.) Woodson ex Munz. Habit of plant and fruit.

2.7-3.7 mm longa, alba vel subrosea, costis viridibus, albidis, vel roseis; achenia immatura 2-2.5 mm longa, viridula.

Shrubby perennial, 1.5-3 dm tall, with few to many erect to ascending branches from woody caudices; leaves on lower 1/5-1/2 (3-10 cm) of the branches of current season, the blades lance-oblong to oblong, elliptic, or oblanceolate, 1.5-3 (3.5) cm long, (0.3) 0.5-1.4 cm broad, entire, crenulate, or more or less revolute, densely whitish tomentose below, densely to moderately tomentose above, the petioles 0.7-2 cm long; current stems densely cobwebby-tomentose, 3-10 cm long; peduncles 6-13 cm long, densely to moderately tomentose; bracts scale-like or subfoliose; inflorescence cymose, with 2-4 (5) main branches 1.5-6 cm long; involucres sessile or subsessile, turbinate, 2.5-4 mm long, 2-2.5 mm wide, tomentose externally, the teeth 0.9-1.3 mm long; perianth 2.7-3.7 mm long, whitish or pinkish, with green, pink, or red midribs; immature achenes 2-2.5 mm long, greenish (Figure 2, Map 3).

Specimens Examined: Utah; Garfield Co., Gravelly, boulder strewn, east-facing slope, near head of canyon, at milepost 26, south of Antimony, along Utah highway 22, in *Artemisia* community, S. L. & S. L. Welsh 9389, 4 Sept. 1969 (Holotype BRY; Isotypes US, NY, ISC, and others); East fork of Sevier R., Utah 22 (Antimony-Bryce Canyon road), T. 32 S., R. 2 W., Sec 26., elevation 7,300 feet, N. H. Holmgren et al 2253, 24 July 1965 (BRY, NY); Bouldery bitch of a slope, dominated by *Gutierrezia*, ca 11.4 miles south of Antimony, along Utah highway 22, S. L. Welsh et al 6486, 24 July 1967 (BRY, ISC, NY).

Eriogonum revealianum is apparently most closely related to *E. corymbosum* var. *corymbosum* (Reveal 1968, 1969), and has probably been derived from that entity. It is unique among the members of the corymbosum complex in having the very short leafy stem and elongate, naked peduncles. Occasionally, some specimens of *E. corymbosum* var. *corymbosum* approach this condition, but not on a population basis. Apparently, *E. revealianum* is confined to the north end of the broad valley north of Bryce Canyon, along a minor drainage of the east fork of the Sevier River. It occurs in a community dominated by *Gutierrezia sarothrae* (Pursh) Britt. & Rusby var. *sarothrae*, *Artemisia nova* A. Nels., *Eriogonum microthecum* Nutt., and *Artemisia pygmaea* Gray.

The species is named in honor of Dr. James L. Reveal, the principal and most energetic student of *Eriogonum*.

Gutierrezia sarothrae (Pursh) Britt. & Rusby
var. *pomariensis* var. nov.

A var. *sarothrae* differt bracteis involucrorum obtusis et floribus longior et plus numerosi.

Suffrutices, 1.2-4.5 dm alti; caules plures vel numerosi, basi persistens ligneo; folia 15-52 mm longa, 0.5-2.5 mm lata, linearia, integra, glabra vel scabra, glandulifera; capitula corymbosa, solitaria

Fig. 2. *Eriogonum revealianum* n. sp.

vel 2-3; involucra 5-7.5 mm longa, 2-5 mm lata, turbinata vel cylindracea, bracteae obtusae late, maculis viridibus subapicalibus, resinosae; flores ligulate 5-9, corollis 2-5 mm longi; flores discus 5-7, corollis 3.5-4.5 mm longis; achenia strigosi, 1-2 mm longi.

Subshrubs, 1.2-4.5 dm tall, the stems several to many from a

Fig. 3. *Gutierrezia sarothrae* (Pursh) Britt. & Rusby var. *pomariensis* n. var.

persistent, woody base; leaves 15-52 mm long, 0.5-2.5 mm broad, linear, entire, glabrous or scabrous, glandular-dotted; heads in corymbose inflorescences, solitary or 2-3 clustered at stem ends; involucres 5-7.5 mm long, 2-5 mm broad, turbinate to cylindric, the bracts broadly obtuse, with a greenish, subapical spot, resin coated;

ligulate flowers 5-9, the corollas 2-5 mm long; disk flowers 5-7, the corollas 3.5-4.5 mm long; achenes hairy, 1-2 mm long (Figure 3, Map 2).

Specimens Examined: Utah; Uintah Co., Sandy flat, base of sandstone cliffs, Frontier formation, mouth of Orchard Creek Draw, Dinosaur National Monument, S. L. Welsh et al 9471, 2 Oct. 1969 (Holotype BRY; Isotypes NY, US); Mouth of Redwash, south boundary, Dinosaur National Monument, S. L. Welsh 403, 3 July 1955 (BRY); With shadscale, on red, silty Uinta formation ca 4 miles west of Maeser, along Utah highway 245, S. L. Welsh and G. Moore 6754, 3 Sept. 1967 (BRY); Moenkopi shale, Split Mt. Gorge campground, Dinosaur National Monument, J. Brotherson 800, 15 July 1965 (BRY), do 803, 25 Aug. 1965 (BRY); Mowry shale, .25 miles west of Quarry, Dinosaur National Monument, J. Brotherson 831, 25 Aug. 1965 (BRY).

In 1955, while making a collection of plants in Dinosaur National Monument, I came across a specimen of *Gutierrezia sarothrae* with exceptionally large heads (Welsh, 1957). The specimen was sent to the late S. F. Blake in Beltsville, Maryland for verification. Dr. Blake commented (personal communication) that the specimen was unusual and apparently was closely related to some Californian members of *Gutierrezia*. The specimen was retained by Dr. Blake, and its present whereabouts is unknown. During the past few years, several specimens of this unusual type have been collected in Uintah County. These have made it possible to analyze the distinguishing features and to provide an adequate description of the entity.

Plants with large heads were also noted by Solbrig (1960, p. 56) in his treatment of *Gutierrezia*. He stated that a few specimens from the Uinta Mountains of northeastern Utah have large heads, similar to those of *G. bracteata* (from California).

In essence, *G. sarothrae* var. *pomariensis*, named for its type locality in Orchard Creek Draw, is distinguished from var. *sarothrae* by its larger heads, broader, obtuse bracts, and more numerous and larger flowers. In addition, the heads tend to be solitary at the ends of the branches of the inflorescence instead of clustered as they are in var. *sarothrae*.

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A REVISION OF THE UTAH SPECIES OF TOWNSENDIA (COMPOSITAE)

James L. Reveal[1]

In 1957, Beaman published his monumental and classical monograph on the genus *Townsendia* Hook. (Compositae, Astereae) which has become a model for several recent taxonomic studies. Beaman commented on several occasions that a critical lack of specimens hindered his research on a few of the species restricted to, or commonly associated with, the Utah flora. With the discovery of a new species in this genus by Welsh and Reveal (1968), it became obvious that since 1957 a great deal of new material had come into herbaria from this area, and with my location at that time at Brigham Young University, it was felt that a revision of the genus was not only in order but could be easily supplemented by additional field work both by myself and my associates at the University.

This revision is based, to a large degree, on Beaman's monograph. I have attempted to supplement his study not only by an examination of newer material, but also by a reexamination of many of the specimens studied by Beaman as well. I have assumed that his concepts of the taxa with regards to their typification is correct although it is necessary now to typify a few names not handled by him in accordance with the International Code of Botanical Nomenclature (Lanjouw, 1966).

I would like to acknowledge the assistance of Dr. Stanley L. Welsh, Curator of the Herbarium, Brigham Young University, who arranged for me to see material from the following herbaria.

A	Arnold Arboretum, Harvard University, Cambridge, Massachusetts.
BRY	Brigham Young University, Provo, Utah.
CAS	California Academy of Sciences, San Francisco, California.
DS	Dudley Herbarium, Stanford University, Stanford, California.
GH	Gray Herbarium, Harvard University, Cambridge, Massachusetts.
MO	Missouri Botanical Garden, St. Louis, Missouri.
MSC	Michigan State University, East Lansing, Michigan.
NA	United States National Arboretum, Washington, D.C.
NY	New York Botanical Garden, Bronx Park, Bronx, New York.
POM	Pomona College Herbarium, Rancho Santa Ana Botanic Garden, Claremont, California.
RSA	Rancho Santa Ana Botanic Garden, Claremont, California.
UC	University of California, Berkeley, California.
US	United States National Herbarium, Smithsonian Institution, Washington, D.C.
UT	University of Utah, Salt Lake City, Utah.
UTC	Intermountain Herbarium, Utah State University, Logan, Utah.

Specimens cited from other herbaria in discussing type material is taken from Beaman's paper in order to make the type citations

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complete. It should be noted, however, that type material from all of the above herbaria was seen in this study.

I would like to thank Dr. Stanley L. Welsh for reviewing this paper.

Townsendia in Utah

The members of the genus *Townsendia* are small and inconspicuous in the Utah flora. They occur among pinyon-juniper and sagebrush early in the spring of the year; later in the year, *Townsendia* flowers on high alpine ridges and slopes in the mountains where it is difficult to collect as well as find. Sereno Watson, with the King expedition in 1868, was the first collector to discover species of this genus in Utah, although to the north in Wyoming, Thomas Nuttall had found several of our species during his trans-continental trip in 1834. Lester Ward, a plant collector hired by John Wesley Powell, gathered specimens in southern Utah in 1875, but in Utah the most active collector of *Townsendia* was Marcus E. Jones. In the last fifty years a great many botanists have been collecting *Townsendia*: P. A. Rydberg, A. O. Garrett, W. P. Cottam, B. F. Harrison, and B. Maguire were early collectors who actively botanized in the state. They were followed by A. H. Holmgren, D. W. Ripley and R. C. Barneby, A. Eastwood and J. T. Howell, J. H. Beaman, S. L. Welsh, L. C. Higgins, N. D. Atwood and J. L. Reveal. All of these people have added many new collections to the various herbaria, and many of these more recent specimens were not available to Beaman.

The genus is primarily found in the Rocky Mountains of the United States. The species extend from the southern part of the Yukon to the central part of Mexico, and from the Columbia River Plateau of central Oregon and Washington to the Great Plains in northeastern Nebraska. Beaman (1957) recognized twenty-one species in the genus, but from the present study, I would recognize twenty-four, with Utah having more species (twelve) than any other state.

Narrow endemism is a common feature in the genus. In many instances, such as in *Astragalus* (Barneby, 1964) and *Eriogonum* (Reveal, 1969), edaphic factors have played a major role in speciation. I agree with Beaman (1957, p. 10) when he wrote: ". . .it may be stated that the acaulescent, rosulate forms require more highly specialized edaphic situations than do the caulescent types." *Townsendia aprica*, *montana*, *minima*, *mensana*, and *jonesii* are all highly specialized in particular edaphic situations in Utah while the remaining species of Utah *Townsendia* are generally found in a wider variety of habitats and on a great range of soil types.

The species concept in *Townsendia* is complicated by two rather intricate and possibly related problems—hybridization and apomixis. That both occur in a single species does not reduce the taxonomic status of the species, nor does the fact that the various species tend to overlap in flowering time reduce the possibilities of recognition of species. Even so, for the most part, the degree of hybridization is limited and hybrids do not seem to occur over large geographical regions so that no question of specific distinctiveness needs to be

raised. The fact that no possible hybridization can occur due to some taxa's geographical isolation has caused me to elevate two varieties recognized by Beaman to the species rank as they express a far greater degree of morphological difference than that found in other variants in the genus. In both cases, it is possible to demonstrate a distinction in morphology as well as edaphic and geographical isolation—features which as Cronquist (1968) has stated allows for the recognition of a species as ". . .the smallest population which is permanently (in terms of human time) distinct and distinguishable from all others."

The role of apomixis has been discussed at great length by Beaman (1957). He points out that in the long-lived, high montane species, they are nearly always apomictic, and in many cases are nearly identical so that the various species may be extremely difficult to distinguish even by the experts. It is suggested that the user of this key to the species be keenly aware of both the morphology and the geographical location of his unknown plant.

The morphological characteristics used to distinguish species in the Utah *Townsendia* are not unique, but rather those frequently used in Compositae. The plants from Utah may be spreading annuals or biennials or highly reduced and compacted perennials. The roots are thick and woody in the perennials, but thinner in the annual plants; all have taproots. The caudices are branched, more or less woody, and often invested with old leaf-bases. The variation in leaf-shape in the genus is of little help in distinguishing species except for the fact that the leaf shape can separate large groups of species. There is a gradual modification of the blade into the petiole, with the variously pubescent leaf-bases clasping the stems. The margins of the leaves are entire; however, the degree of revoluteness varies between and within some species. In general, thickened leaves are found in the plants of higher elevations. Stem and leaf pubescence is essentially strigose and the amount of pubescences is an important taxonomic criteria. The involucres are campanulate to obconical with the phyllaries varying in both length-width ratio and the amount of pubescence. The margins of the phyllaries are usually ciliated.

The color of the ray-flowers vary from white to pink or blue except in *Townsendia aprica* which has distinctly yellowish rays (the rays of *T. jonesii* may dry yellowish on some plants). The adaxial surface is glabrous, but the abaxial surface varies from glabrous to densely glandular. The disk-flowers are yellowish except for the tips which may be reddish to purplish or greenish tinged. Achene shape and pubescence are important taxonomic features in the genus. The shape varies from narrowly oblanceolate to obovate and they are variously compressed with ribbed or callous-thickened margins. The pappus has been widely used in the genus as a key character, but it seems to be of limited value except in separating major groups of species. The length of the ray and disk pappus may be equal or different in the same species although it is not too uncommon to find

some diversity in a single plant. The bristles are always free on the disk-flowers, but they may be connate on the rays so as to become a ring of coroniform squamellae around the apex of the achenes.

Systematic Treatment

Townsendia Hook., Fl. Bor.—Am. 2: 16, pl. 119. 1834.

Annuals or fore frequently biennials or perennials, caulescent or acaulescent herbs from taproots, these terminated by suberect, decumbent or rosulate woody caudices; leaves alternate, spathulate to linear, entire, glabrate to densely pubescent with few- to many-celled trichomes; heads pedunculate or terminal on stems or sessile and submerged in tufts of basal leaves; involucres campanulate to obconical, the phyllaries imbricated in 3-7 series, linear to obovate, ciliated along the margins, glabrous to pubescent; ray-florets pistillate, fertile, uniseriate, mostly 13-40, the ray-corollas broadly linear to oblong-linear, blue, whitish, pink, or yellowish on the adaxial surface, darker on the abaxial surface, glabrous or glandular; disk-florets hermaphroditic, numerous, the disk-corollas yellow and frequently pink- or purplish-tipped or tinged, glabrous or slightly glandular; achenes oblanceolate to obovate, compressed, 2-ribbed, glabrate or more frequently pubescent with simple, bifurcate hairs with prongs of an unequal length, or glochidiate with recurved prongs of essentially equal length; disk-pappus uniseriate of terete or obcompressed, plurisetose, barbellate bristles; ray-pappus similar to that of the disk or variously reduced or squamellae; x=9. Type species: *Aster exscapa* Richards. [= *Townsendia exscapa* (Richards.) Porter.] Named for David Townsend (1787-1858), an amateur botanist of West Chester, Pennsylvania, and a botanical associate of William Darlington.

Key to the Species

1. Plants long-lived perennials.
   2. Phyllaries broadly lanceolate to ovate or elliptic, in 2-5 series.
      3. Plants acaulescent, rosulate-pulvinate.
         4. Corolla-rays yellowish to golden-yellow, densely grandular on the abaxial surface; leaves strigose; rare, Sevier Co. 1. *T. aprica*
         4. Corolla-rays white, pink or blue, or if drying yellowish, then plants not from Sevier Co.
            5. Leaves linear, with dense tufts of long, simple trichomes at the base; Uinta Basin, Duchesne and Uintah cos. 4. *T. mensana*
            5. Leaves oblanceolate to spathulate.
               6. Achenes glabrous; leaves glabrous or only slightly strigose in some; high mountains in northern Utah above 9000 feet. 2. *T. montana*
               7. Achenial hairs simple or unevenly bifurcated with one prong exceeding the other, rarely truly glochidiated; leaves glabrous or sparsely strigose, thickened; Bryce Canyon area, Garfield Co. 3. *T. minima*
               7. Achenial hairs mainly glochidiate, rarely with scattered

unevenly pronged hairs in *T. jonesii;* leaves moderately to densely strigose.

8. Phyllaries glabrous or the outer ones only slightly pubescent; ray-corollas densely glandular; western Utah. 5. *T. jonesii*

8. Phyllaries conspicuously strigose; ray-corollas glabrous to lightly glandular; eastern and southwestern Utah. 10. *T. incana*

3. Plants caulescent with spreading-suberect stems; achenial hairs unevenly branched, not glochidiate; deserts of western Utah. 9. *T. florifer*

2. Phyllaries linear to narrowly lanceolate, in 5-7 series.

9. Phyllaries with a tuft of tangled cilia at the apex, linear, acuminate at the apex; leaves linear or narrowly oblanceolate, involute, sericeous-canescent; Carbon, Duchesne, and Daggett cos., rare. 7. *T. hookeri*

9. Phyllaries without a tuft of tangled cilia at the apex, narrowly lanceolate, acute at the apex.

10. Ray-corollas densely glandular on the abaxial surface; leaves linear with dense tufts of long, simple trichomes at the base; Uinta Basin, Uintah and Duchesne cos. 4. *T. mensana*

10. Ray-corollas glabrous or only sparsely pubescent.

11. Disk-pappus 3-6 mm long; leaf midveins not conspicuous; mountains of northern Utah. 6. *T. leptotes*

11. Disk - pappus 6-11 mm long; leaf midveins conspicuous; low mountains of southern Utah. 8. *T. exscapa*

1. Plants annuals or biennials.

12. Disk-pappus as long as or longer than the disk-corollas.

13. Achenial hairs unevenly branched, not glochidiate; plants caulescent with spreading-suberect stems; deserts of western Utah. 9. *T. florifer*

13. Achenial hairs glochidiate; eastern and southwestern Utah.

14. Stems among the leaves gray-white with a dense canescent pubescence; phyllaries strigose on the outer surface; eastern and southwestern Utah. 10. *T. incana*

14. Stems merely lightly to moderately strigose with the red stems among the leaves obvious; phyllaries moderately strigose on the outer ones, slightly so if at all on the inner ones; northeastern Utah. 11. *T. strigosa*

12. Disk-pappus shorter than the disk-corollas; phyllaries glabrous to moderately strigose-pilose, elliptical, obovate, or ovate to obtuse; southeastern Utah. 12. *T. annua*

Description of the Species

1. Townsendia aprica Welsh and Reveal

Townsendia aprica Welsh & Reveal, Brittonia 20: 375. 1968. Type: Ca. 6 mi S of Fremont Jct., Sevier Co., Utah, along Utah Hwy. 72, on low rolling gray clay slopes, among scattered igneous boulders, associated with *Juniperus* and *Castilleja*, at ca. 6500 ft., 1 May 1966, *Reveal & Welsh 721.* Holotype, BRY! Isotypes, CAS, GH, MSC, NY, UC, US, UTC!

Rosulate-pulvinate caespitose perennial herbs from a much-branched partially subterranean caudex arising from a thin taproot,

the upper branches of the caudices often clothed with persistent leaf-bases usually bearing long white hairs, the plants 2-6 cm across, less than 2.5 cm high; leaves spathulate to oblanceolate, entire, the apex acute, minutely mucronate, strigose evenly or nearly so on both surfaces, tapering gradually to the leaf-base, the leaf-base 1-1.3 mm wide, essentially glabrous on the adaxial surface, with dense strigose erect-appressed hairs along the margin and abaxially, the broad leaf-base tapering toward the leaf-blade, the narrowest point being 3-6 mm above the point of attachment, 7-13 (16) mm long, (1) 1.5-3 (3.5) mm wide; peduncles lacking; involucres obconical at the base, 4-8 mm high, 7-13 mm wide; phyllaries in 3-4 series, lanceolate, the apex acute, fimbriated, red-scarious, the hyaline cilia numerous and densely arranged, glabrous adaxially, the outermost series occasionally sparsely strigose abaxially, otherwise glabrous, 5-7 mm long, 0.9-1.8 mm wide, the inner ones the longest; ray-florets 13-21; ray-corollas yellowish to golden adaxially, glabrous, reddish to rustic with yellowish margins abaxially, rather densely glandular throughout, the tube 1.8-2.9 mm long, greenish or rustic, sparsely glandular, the rays spreading to erect, 4-7 mm long, 0.8-2.2 mm wide; disk-corollas yellow, tinged with purple at the tip, 3.7-4.5 mm long; achenes narrowly oblanceolate, 2-2.5 mm long, 0.5-0.7 mm wide, compressed, 2-ribbed, nearly glabrous along the ribs, densely pubescent on the wide compressed surfaces with long tangled hyaline glochidiate hairs with the apex bifurcated into two recurved tips; pappus of the ray-flowers 0.7-1 mm long of about 15 plurisetose, barbellate bristles, these tending to be united at the base, occasionally with some individual bristles as short as 0.3 mm long on the same achene; pappus of the disk-flowers similar, only 4-5 mm long and free.

Distribution: Known only from Sevier Co., Utah, on heavy clay soils. Flowering from April to May.

Specimens Examined: Sevier Co.: Ridge between Cottonwood and Willow creeks, 31 May 1940, *Robinette 105 L. R.* (NA); at Milepost 28.3 North of Fremont, Welsh, Atwood and Higgins 8972, 10 May 1969 (BRY).

The need for this revision was initiated mainly by the discovery of *Townsendia aprica* as it was necessary to investigate the related species in some detail before the exact nature of this new entity could be determined. As suggested by Welsh and Reveal (1968), *T. aprica* is related to both *T. minima* and *T. jonesii*. The leaves of *T. minima* are glabrous or nearly so with rounded apices on truly spathulate leaves. The leaves of *T. jonesii*, while pubescent as in *T. aprica*, are decidedly longer and much narrower than in *T. aprica*, and not at all glandular as in *T. aprica*. While the peduncles are obsolete in both *T. minima* and *T. aprica*, the peduncles of *T. jonesii* are often up to 3 cm long in some populations. The achene hairs of *T. minima* are bifurcated, while in *T. jonesii*, the hairs are glochidiate and only rarely are some bifurcate hairs seen. Apparently the hairs on the achenes in *T. aprica* are always glochidiate.

The most distinctive feature of *Townsendia aprica* is the presence of yellow or golden colored rays. This is a consistent feature of the species and is apparently a reflection of its genetic makeup instead of some type of artifical response—such as drying upon being pressed. In some populations of *T. jonesii*, a yellowish cast has been recorded, but the yellowishness is dull and is not seen in the field. Until *T. aprica* was discovered, yellow rays were unknown in the genus and in using present floras of the state (Rydberg, 1917; Tidestrom, 1925; Welsh, et al. 1964), it is impossible to key this species to the genus *Townsendia*.

2. Townsendia montana M. E. Jones

Townsendia montana M. E. Jones, Zoe 4: 262. 1893. Type: Above the Flagstaff Mine at Alta, 9500 ft elev, Salt Lake Co., Utah, 7 Aug 1879, *M. E. Jones s.n.* Holotype, POM!

Townsendia alpigena Piper, Bull. Torrey Bot. Club 27:394. 1900. Type: Subalpine ridges of the Wallowa Mountains, 7000 ft elev, Wallowa Co., Oregon, 31 Jul 1899, *Cusick 2294*. Holotype, WS! Isotypes, F, GH, MO, MSC, UC, US! Lectotype selected by Beaman (1957).

Townsendia dejecta A. Nels., Bot. Gaz. 37: 267. 1904. Type: Dyer Mine, Uinta Mountains, ca. 9000 ft elev, Uintah Co., Utah. 3 Jul 1902, *Goodding 1238*. Holotype, RM. Isotypes, MO, US!

Rosulate-pulvinate caespitose perennial herbs from a much-branched, relatively elongated, subterranean woody caudex arising from a woody taproot, the upper branches of the caudices usually lacking persistent leaf-bases but with persistent leaf-scars on the naked older branches, the plants up to 10 cm across and 4 cm high; leaves spathulate to broadly elliptical, entire, the apex obtuse to acute, not mucronate, nearly or quite glabrous except on the youngest leaves, these often sparsely strigose, tapering gradually to the leaf-base, the leaf-base 0.8-1.5 mm wide, often sparsely strigose along the margins and anthrocynsis, the petiole 0.8-2.6 mm long, the leaf-blades 4-12 (15) mm long, 2.5-3.2 (5) mm wide; peduncles present, scapose or nearly so, enlarged at the junction with the head, pilose-strigose, 6-35 mm long; involucres obconical at the base, 7-11 mm high, 9-15 mm across; phyllaries in 3-6, mostly 4, series, oblong to obovate, obtuse and rounded at the apex, with red-scarious ciliated margins, glabrous or with a few scattered strigose hairs on the outer phyllaries on the abaxial surface, 3-8 mm long, 1.9-3.2 mm wide, the inner ones the longest; ray-florets 13-21; ray corollas white or dark blue, glabrous or sparsely glandular on the abaxial surface, the rays 6-9 mm long, 1-3.5 mm wide, the tubes 2-3 mm long, yellowish; disk-corollas yellow, tinged with green at tthe tip, 3-5 mm long; achenes oblanceolate, compressed, 2-ribbed, those of the rays rarely 3-ribbed, glabrous or with a few glochidiate hairs at the extreme base, (2) 3-4.5 mm long, 1-1.5 mm wide; pappus of the ray-flowers

of about 15-30 plurisetose barbellate bristles, 3-5.5 mm long, free; disk-pappus similar to the ray-pappus. 2n= 18 (Beaman, 1957).

Distributions High mountains of western Montana and central Idaho southward through western Wyoming into central and northeastern Utah with an outlying population in northeastern Oregon. Flowering from (May) June to August.

Representative Specimens: Cache Co.: Saddle of Mt. Naomi, 22 Jul 1936, *Maguire et al. 14227* (UTC). Duchesne Co.: 14 mi S of Duchesne, 18 May 1908, *Jones s.n.* (POM). Juab Co.: N Peak, Mt. Nebo, 7 Jul 1959, *Cottam et al. 15577* (UT). Salt Lake Co.: Flagstaff Mine near Alta, 24 Jul 1954, *Beaman 843* (GH, MSC); Sunset Peak, 14 Jun 1960, *Cottam & Rowland 16152* (UT, UTC); Pioneer Peak, 22 Jun 1961, *Cottam & Rowland 16710* (UT); ridge between Sunset Peak and Devils Castle, 29 Jun 1961, *Cottam & Rowland 16771* (UT); head of Little Cottonwood Creek, 3 Jul 1905, *Rydberg 6607* (NY, US). San Pete Co.: Mt. Baldy, Wasatch Plateau, 16 Jul 1954, *Beaman 806* (GH, MSC, RSA, UTC); Horseshoe Mtn., Jul 1946, *Goodwin 46Jy3* (NA); head of Bacon Rhine Canyon, 22 Jul 1927, *Humphrey s.n.* (BRY); Mayfield Canyon, 8 Aug 1940, *Maguire 19987* (GH, NY, US, UTC). Summit Co.: divide between the E Fork of the Bear River and Black's Fork, 9-13 Jul 1930, *Goodman & Hitchcock 1517* (GH, NY, in part). Uintah Co.: White Rock Canyon, 17 Aug 1935, *Graham 10065* (NA).

Townsendia montana is found in the high mountains of Utah from Cache Co. in the north to the Wasatch Plateau of San Pete Co. in the south, and eastwardly into the Uinta Mountains of Summit and Uintah cos. This species is related to *T. eximia* A. Gray and *T. glabella* A. Gray, both of which are restricted to the mountains of Colorado and New Mexico.

In Utah, this species has essentially blue flowers and commonly grows in rocky or gravelly places on high mountain plateaus, ridges, or shallow soiled slopes. The populations are highly isolated and often individually distinct due to apomixis; however, the number of plants in any one population may be relatively large. The plants from the type area near Alta, for example, have wide, blue to dark blue rays on glabrous plants with dark green leaves. Those found on the Wasatch Plateau, on the other hand, have white to pink or light blue rays on plants that are not as dark green. The plants of northern Utah tend to be more compact and less elongated than those in central Utah. Members of this species are usually found intermixed among various grass species in the open places between clumps or even under clumps of the various forms of *Artemisia*, the sagebrushes.

Among the Utah species of *Townsendia*, *T. montana* can be rather easily distinguished by the blue rays which are glabrous to sparsely glandular and the glabrous achenes.

3. Townsendia minima Eastw.

Townsendia minima Eastw., Leafl. West. Bot. 1: 206. 1936. *T. montana* var. *minima* (Eastw.) Beaman, Contr. Gray Herb. 183: 85. 1957. Type: Bryce Canyon, Garfield Co., Utah, 19 Jun 1933, *Eastwood & Howell 727*. Holotype, CAS!

Rosulate-pulvinate caespitose perennial herbs from a much-branched, elongated, subterranean caudex arising from a wood taproot, the upper branches of the caudices clothed with persistent leaf-bases for 1-5 cm so as not to expose the leaf-scars, the plants up to 15 cm across and 5 cm high; leaves narrowly spathulate or oblanceolate, entire, the apex obtuse or more commonly acute, often mucronate, thinly strigose (especially in young plants and on new growth) becoming glabrous or nearly so on the adaxial surface, (3) 4-8 mm long, 1.2-3 mm wide, the blades tapering gradually onto the petioles, these 5-9 mm long, strigose especially along the margins, the leaf-bases not often antrocynsis; peduncles lacking; involucres obconical at the base, 6-10 mm across, 5-8 mm high; phyllaries in 3-4 series, oblanceolate, mostly acute at the apex, with red-scarious ciliated margins, strigose abaxially, 3-7 mm long, 0.9-2.1 mm wide, the inner ones the longest; ray-florets 13-21; ray-corollas pink to light blue, sparsely glandular on the abaxial surface, the rays 4-8 mm long, 1.5-2.1 mm wide, the tubes 1.8-2.5 mm long, pinkish; disk-corollas yellow, tinged pink to purplish at the tip, 3-4 mm long; achenes oblanceolate, compressed, 2-ribbed, those of the rays rarely 3-ribbed, long pubescent with fine unequally forked hairs, 2-3 mm long, 0.9-1.4 mm wide; pappus of the ray-flower of 15-30 plurisetose barbellate bristles, 3-5 mm long, rarely shortened, free; disk-pappus similar to the ray-pappus. 2n = 18 (Beaman, 1957).

Distribution: Endemic to the Red Canyon and Pink Cliffs area near and in Bryce Canyon, and southward to near Orderville, Garfield and Kane cos., Utah. Flowering from April to June.

Representative Specimens: Garfield Co.: 2 mi E of Jct. of U.S. Hwy. 89 and Utah Hwy. 54, 21 Jul 1954, *Beaman 823* (GH, MSC); S of garbage dump, Bryce Canyon, 8 Jun 1958, *Buchanan 349* (UT); above Tropic, 29 May 1894, *Jones 5312ar* (NY, POM, US); Paria River, Pink Cliffs, 25 Jun 1940, *Maguire 19099* (NY, UTC); 1 mi E of Pine Lake, Pink Cliffs, 26 Jun 1940, *Maguire 19120* (GH, NY, UTC); E fork of Sevier River, 3.5 mi S of Utah Hwy. 12, 25 May 1968, *Reveal & Reveal 1010* (BRY, US); low ridge N of E Fork of the Sevier River Road, N of Utah Hwy. 12, 25 May 1968, *Reveal & Reveal 1018* (BRY, US); top of ridge S of Red Canyon Campground, 25 May 1968, *Reveal & Reveal 1027* (BRY, US); do, *N. D. Atwood 1885* (BRY) 20 Jun 1869; NE of Widtsoe, 26 May 1968, *Reveal & Reveal 1035* (BRY, US); Red Canyon, 7 Jun 1947, *Ripley & Barneby 8540* (CAS, NY). Kane Co.: 15 mi NW of Orderville, 17 Jun 1940, *Maguire 18807* (UTC).

Townsendia minima was described as a distinct species by Eastwood in 1936, but reduced to a variety of *T. montana* by Beaman

some twenty years later. In the present paper, I am proposing that Eastwood's original desposition for the population be retained. I certainly agree with Beaman (1957) that this species is related to *T. montana*, but morphologically the two differ in leaf and achene pubescence, the size of the leaves, the degree of persistence of the leaf-bases and—for the most part—the color of the rays. The two species differ greatly in ecological and particularly in the type of soils on which they grow. *Townsendia minima* occurs at lower elevations than *T. montana*, in open exposed sites on heavy soils of the Wasatch Formation. This combination of features has led me to consider the two entities as distinct species.

This species is common in Red Canyon, a well known area for its interesting botanical endemics. The canyon, part of the Dixie National Forest, is now heavily used by recreation visitors, and is in danger of being so over-used that these unique and usually exceedingly rare species may be lost. *Eriogonum aretioides* Barneby is known from only a few plants in about three scattered locations. *Silene petersonii* Maguire and *Townsendia minima* are only occasionally found as is *Lesquerella rubicundula* Rollins and the recently described *Cryptantha ochroleuca* (Higgins, 1968). *Oxytropis jonesii* Barneby is locally encountered, but it is never abundant. These interesting species, all of which occur on the lower slopes and in the bottom of the canyon, are often subjected to destruction by nature as well as by man, and some control of the Red Canyon area will have to be made if this canyon is to remain a pleasant and attractive recreation site.

4. Townsendia mensana M. E. Jones

Townsendia mensana M. E. Jones, Contr. West. Bot. 13: 15 1910. Type: Benches of the Uintas near Duchesne [then called Theodore], at about 7500 ft elev, Duchesne Co., Utah, 14 May 1908, *M. E. Jones s.n.* Holotype, POM!

Rosulate-pulvinate caespitose perennial herbs from a much-branched short, woody subterranean caudex arising from a well-developed woody taproot, the upper branches of the caudices often clothed with persistent leaf-bases, the plants up to 1 cm across and 5 cm high; leaves narrowly oblanceolate to linear, entire, the apex acute, mucronate, evenly strigose on both surfaces, involute, (4) 6-14 mm long, 0.8-1.3 mm wide, the blades tapering inperceptably to the leaf-base, the abaxial surface of the leaf-base densely woolly with long, white, multicellular trichomes; peduncles lacking; involucres obconical at the base, 6-9.5 mm across, 5-9 mm high; phyllaries in 4-5 series, lanceolate, acute at the apex, margins ciliated, green and glabrous to sparsely glandular or lightly strigose-pilose on the outer surface, 3.5-8 mm long, 1.2-1.8 mm wide, the longer inner ones often reflexed; ray-florets 13-21; ray-corollas whitish or pinkish, often with pale pinkish streaks and fine brownish lines abaxially, glandular on the abaxial surface, the rays 5-7.5 mm long, 0.9-1.4 mm wide, the tubes 3-3.8 mm long, whitish; disk-corollas

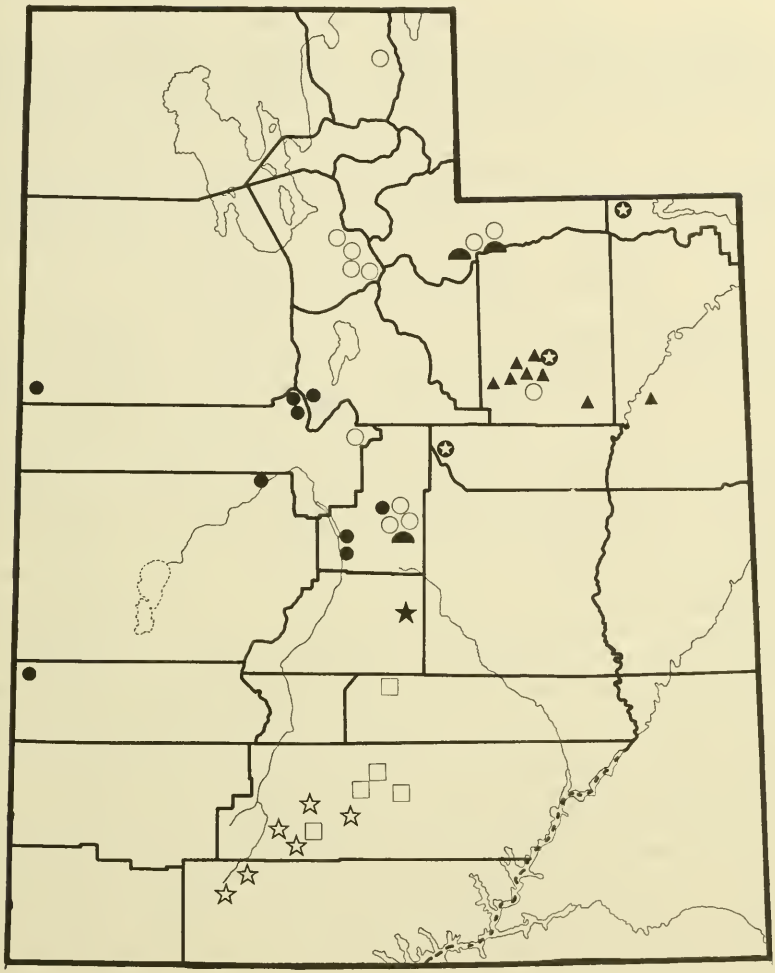

Fig. 1. Distribution of *Townsendia aprica* (star); *T. montana* (open circles); *T. minima* (open stars); *T. mensana* (triangles); *T. jonesii* (closed circles); *T. leptodes* (half circles); *T. hookeri* (circles with star in center); and *T. exscapa* (squares).

yellow, often tinged pink at the tip, 3.5-4.8 mm long; achenes oblanceolate, compressed, 2-ribbed, densely pubescent on all surfaces with glochidiate hairs; pappus of the ray-flowers of 15-35 plurisetose barbellate bristles, 2.5-4 mm long, free; disk-pappus similar to the ray pappus only 5-6.5 mm long.

DISTRIBUTION: Endemic to the Uinta Basin of northeastern Utah in Duchesne and Uintah counties mainly on pinyon-juniper mesas in rocky places. Flowering from late April to June.

Specimens Examined: Duchesne Co.: 26 mi SW of Myton, 15 May 1955, *Barneby 12701* (CAS); 15 mi W of Duchesne, 29 Jul 1954, *Beaman 865* (GH); 3 mi SW of Duchesne, 30 Jul 1954, *Beaman, 866* (GH); 11 mi N of Duchesne, 30 Jul 1954, *Beaman 868* (GH, MSC); 5 mi W of Duchesne, 26 Jul 1957, *Beaman & Stone 1447* (MSC); 19 mi W of Duchesne, 4 May 1968, *Reveal & & Reveal 961* (BRY, US); 1.5 mi W of Jct. Utah Hwy 35 and ca. 8 mi N of Duchesne, 4 May 1968; *Reveal & Reveal 965* (BRY, US); 3 mi W of Duchesne, 30 May 1942, *Ripley & Barneby 4677* (CAS). Uintah Co.: Between Hill Creek and Green River, ca. 20 mi S of Ouray, Jun 1955, *Bartholomew & Bartholomew s.n.* (GH).

Townsendia mensana is a rare and local species endemic to the Uinta Basin of northeastern Utah. In the Duchesne area, where most of the collections have been made, the species occurs on the low pinyon-juniper "benches" or mesas where the low stature and the pale color of the plants easily blend into the ground. The single collection made in Uintah County was taken from white shale slopes of the Green River Formation in the Hill Creek area. This latter population differs only slightly from those taken from the gravelly soils; however, additional collections from Hill Creek would be desirable.

During the spring of 1968, I found this species in several locations, but all essentially around the Duchesne area. In most places this species is found growing in association with *Cryptantha nana* Eastw., *Phlox hoodii* Rich., *Oxytropis sericea Pursh var. sericea* A. Gray, and *Eriogonum tumulosum* (Barneby) Reveal under *Pinus edulis, Engelm.* and *Juniperus osteosperma* (Torr.) Little. Most often the plants of the *Townsendia* are found in open areas among the various plants mentioned above, but almost always on heavy clay or rocky soils. The populations examined north of Duchesne grew on loose gravelly soil and on a cobble stone soil derived from a river bed. One population three miles west of Duchesne is on an exposed clay ridge similar to that found at the type locality of *Lepidium barneybyanum* Reveal (1967) where it is associated with both *Eriogonum batemanii* M. E. Jones and *E. tumulosum*, the *Oxytropis, Silene acaulis* L. ssp. *subacaulescens* (F. N. Will.) Hitchc. & Maguire, *Chamaechaenactis scaposa* (Eastw.) Rydb. var. *parva* Preece & Turner, and *Artemisia arbuscula* Nutt. var. *nova* (A. Nels.) Crong. Further to the west, *T. mensana* is found on an exposed clay outcrop which is less than five feet high, about ten to thirty feet wide, and perhaps six hundred feet long. Here the *Townsendia* is found associated with the *Cryptantha* and the *Phlox*, a species of *Lesquerella*, and *Pediastrum alpinum* (Nutt.) A. Gray var. *ligulatum* M. E. Jones. As can be seen, in nearly all cases where *T. mensana* is found, it is growing with a rather unique series of species.

In the past, *Townsendia mensana* has been confused with what is now called *T. hookeri* Beaman, but what in turn was known in the literature prior to Cronquist (1955) and Beaman (1957) as *T. Sericea*. Cronquist pointed out that *T. sericea* was a synonym of *T.*

exscapa and took up the name *T. mensana* for those plants. It was not until Beaman was able to study the type of *T. mensana* that it was realized that this species was highly restricted and a plant (ie. *T. hookeri*) which has been known for more than a century to numerous taxonomists was actually unnamed.

Townsendia mensana may be distinguished from *T. jonesii*, its nearest relative, by its narrow leaves and phyllaries, and the sessile flowering heads.

5. Townsendia jonesii (Beaman) Reveal

Townsendia jonesii (Beaman) Reveal, stat. & comb. nov, based on *T. mensana* M. E. Jones var. *jonesii* Beaman, Contr. Gray Herb. 183: 88. 1957. Type: Mammoth, 7000 ft elev, Juab Co., Utah. 10 May 1910, *M. E. Jones s.n.* Holotype. POM!

Rosulate-pulvinate caespitose perennial herbs from a much-branched, short, or more commonly long, woody subterranean caudex arising from a well-developed taproot, the upper branches of the caudices often clothed with persistent leaf-bases, the plants up to 3 cm high and 10 cm across; leaves narrowly oblanceolate to narrowly spathulate, entire, the apex mostly acuminate, mucronate, moderately strigose on both surfaces, plane or infrequently involute. (1) 1.8-3:5 (4) cm long, 1-2.5 (4) mm wide, the blades gradually tapering to the leaf-base, the abaxial surface of the leaf-base strigose; peduncles present, up to 3 cm long, strigose; involucres obconical at the base, 8-13 mm wide, 9-12.5 mm long; phyllaries in 4-5 series, lanceolate, mostly acute at the apex, margins ciliated, green or purplish nearly throughout, sparsely strigose in the middle of the outer surface, 4-10 mm long, 1-2 (2.5) mm wide, the longer inner ones erect; ray-florets 13-21; ray-corollas whitish to pink, often drying a dull yellow, occasionally with a darker streak abaxially, densely glandular on the abaxial surface, the rays 4-7 mm long, 1-2 mm wide, the tubes 2.5-4 mm long, light green to white; disk-corollas yellow, usually purplish tinged at the tip, 3.5 mm long; achenes oblanceolate, compressed, 2-ribbed, those of th eray-florets rarely 3-ribbed, 3-5.5 mm long, 0.8-1.8 mm wide. ± densely pubescent on the faces with glochidiate hairs, these rarely intermixed with unequally pronged hairs toward the apex; pappus of the ray-flowers of 15-30 plurisetose, barbellate bristles, 2-4.5 mm long, free; pappus of the disk-flowers similar only 5-8 mm long.

Distribution: Infrequent to rare in west-central Utah and adjacent extreme east-central Nevada, with an outlying series of populations in the Sheep Range and Charleston Mountains of Clark Co., Nevada. Flowering from March to June.

Representative Specimens: Beaver Co.: Top of Needle Ranges, 5 mi S of Mountain Home Spring, 31 May 1965, *R. Holmgren 458* (BRY). Juab Co.: McIntyre's Ranch, 18 May 1891, *Jones s.n.* (POM); Tintic Junction, 9 May 1910, *Jones s.n.* (POM). San Pete

Co.: 2 mi SE of Ephraim, 16 Jul 1954, *Beaman 820* (GH, MSC); 5 mi W of Fayette, 12 May 1962, *Jensen 546* (UTC); Gunnison, 7 Jun 1910, *Jones s.n.* (POM); 2.8 mi E of Ephraim, 18 May 1968, *Reveal & Reveal 1001* (BRY, US). Tooele Co.: Deep Creek, 6 Jun 1891, *M. E. Jones s.n.* (POM). Utah Co.: Mercur, 6 Jun 1896, *Jones s.n.* (MO, NY, POM, US, UTC).

Townsendia jonesii was first described by Beaman (1957) as a variety of *T. mensana* to which it is probably closely related. The elevation of this western Utah taxom to the specific rank comes as a result of recent field and herbarium studies carried out in the spring seasons of 1967 and 1968. In general, *T. mensana* is a low, inconspicuous plant with sessile heads, linear leaves with dense tufts of hairs at the base, and the lanceolate phyllaries. *Townsendia jonesii*, on the other hand, is usually not so low or inconspicuous, and generally the heads are peduncled, with wider and longer leaves which are much less pubescent at the leaf-bases, and broadly lanceolate to narrowly obovate phyllaries. Ecologically the two species are somewhat similar, although *T. jonesii* is more frequently found in areas among *Artemisia tridentata* Nutt. and on more sandy soils than *T. mensana*.

The geographical separation of these two species makes them distinctive too. The western desert regions of Utah have several plants that have closely related forms in the Uinta Basin. Some examples are in such genera as *Astragalus*, *Penstemon*, and *Eriogonum;* and, in nearly all cases, the taxa are separated at the specific level. While it is obvious that the two species of *Townsendia* are related, *T. jonesii* seems to form hybrids with *T. florifer* (Beaman, 1957). However, this hybridization does not seem to destroy the specific distinction between the two supposed parents.

During the course of this study, several attempts have been made to rediscover *Townsendia jonesii* in its type locality. The species was not found. The entire area around Eureka, Mammoth, and Tintic has greatly changed over the years since Jones visited these mining communities. Dr. S. L. Welsh has studied the flora in the Tintic area with a great deal of concentration on finding plants named by Jones from this area. However, the *Townsendia* has eluded him too. I. E. Diehl, who lived at Mammoth and actively collected plants in the area apparently did not find the species either, or at least a specimen of his is not among his personal collection deposited at Brigham Young University or in the Jones collection now found at the Rancho Santa Aana Botanic Garden. Certainly, *T. jonesii* must be in the area, but where still remains to be discovered.

Both Heiser (1948) and Beaman (1957) were puzzled by the plants from the high mountains of Southern Nevada. In the herbarium, Heiser decided to distinguish the southern Nevada plants as a distinct species, but shortly afterwards called the plants *T. arizonica*, a synonym of *T. incana*. Beaman recognized the difference between the Utah and Nevada populations of his var. *jonesii*, but decided at that time not to attempt to make a taxonomic distinction

between the two. During this study, it has been possible to note additional morphological characters as well as ecological differences that point out the distinctiveness of the southern Nevada plants. However, these differences do not seem to be great enough to merit specific recognition, and thus may be called:

TOWNSENDIA JONESII (Beaman) Reveal var. TUMULOSA Reveal

Townsendia jonesii (Beaman) Reveal var. *tumulosa* Reveal. var. nov. Type: Ca. 1 mi N of Deer Creek along the Hwy. toward Lee Canyon on gravelly limestone slopes associated with *Abies* and *Pinus*, 8400 ft elev, sec. 8, T. 19 S., R. 57 E., Charleston Mountains. Clark Co., Nevada, 17 Jun 1968, *Reveal 1326*. Holotype, BRY! Isotypes. NTS, NY, UTC!

A var. *jonesii* differt folis 1-2 (2.5) cm longis, (2) 2.5-3.8 (4.2) mm latis, capitulis pedunculatis usque ad 1.5 cm longis, phyllaris late lanceolatis vel obovatis. obtusis, 1.8-3 mm latis.

Herbae perennes, rosulatae-pulvinatae, caudicubus ramosis proparte subterraneis partim e radice gracili; plantae 2-10 cm latae, minus quam 3 cm altae; folia spathulata vel late oblanceolata, integra, ± uniformiter strigosa supra et subtus, raro glabra supra 1-2 (2.5) cm longa, (2) 2.5-3.8 (4.2) mm lata; pedunculi usque ad 1.5 cm longi; involucra (7) 8-12 (14) mm lata, 8-10.5 mm alta, obconica; phyllaria 4-5 seriata, late lanceolata vel obovata, apice obtusa, apice obtusa, fimbriata, scariosi-marginata, cilis numerosis, supra glabra vel apice strigosa, 4-9 mm longa, 1.8-3 mm lata; corollae radii ca. 13-21, ligulis 5-7 mm longis, 0.8-1.3 mm latis, supra albis vel rosis et glabris, subtus rubellis ad rubiginosis, aliquantum ubique dense glanduliferis, tubo 2.8-4 mm longo, albo; corrollae disci flavae. purpurascenti-tinctae, 4.5-6 mm longae; achenia oblanceolata, 3-5 mm longa, 0.8-1.5 mm lata, compressa, pubescentia; pappus flosculorum radiorum 3-4.5 mm longorus; pappus flosculorum discorium 6-7 mm longorum, setis basaliter libris.

DISTRIBUTION: Upper slopes of the Sheep Range and Charleston Mountains from about 6900 ft elev to nearly 10,000 ft elev, Clark Co., Nevada. Flowering from March to June.

SPECIMENS EXAMINED: NEVADA: Clark Co.: Deed Creek, Charleston Mts., 13 June 1939, *Alexander 774* (UC); between Deer Creek and Kyle Canyon, Charleston Mts., 17 June *Alexander 780* (UC); Hidden Forest, Sheep Range, 25 May 1940, *Alexander & Kellogg 1558* (CAS, NA, UC); S slope of Hayford Peak, Sheep Range, 27 May 1940, *Alexander & Kellogg 1568* (NA, UC); Hayford Peak, Sheep Range, 7 Jun 1940, *Alexander & Kellogg 1676* (UC); S of Deer Creek, Charleston Mts., 4 Jun 1937, *Clokey 7772* (UC); Lee Canyon, Charleston Mts., 22 Jun 1937, *Clokley 7773* (UC; Clark Canyon, Charleston Mts., 24 Mar 1934, *Jaeger s.n.* (POM); 5 mi NE of Charleston Peak, Charleston Mts., 21 Jun 1937, *La Rivers & Hancock 487* (NA); Hidden Forest, Sheep Range, 13 Jun 1968, *Reveal 1283* (NTS, NY, UTC); Lee Canyon, Charleston Mts., 11

Apr 1939, *Ripley & Barneby 2910* (UC); head of Deadman Creek, Sheep Range, 19 May 1938, *Train 1777* (NA).

The var. *tumulosa* is rather distinct in the field, and much more common than any of the known sites of var. *jonesii*. It occurs on loose sandy slopes usually under *Pinus ponderosa* Dougl. ex Laws., and is frequently associated with *Artemisia*. However, unlike most of the populations of var. *jonesii*, the var. *tumulosa* occurs in open and exposed places where the surrounding shrubs or even herbaceous perennials afford little or no protection. One may sepculate that this is due to the higher altitude at which this new variety occurs, but such judgements have little documentation.

6. Townsendia leptotes (A. Gray) Osterh.

Townsendia sericea Hook. var. *leptotes* A. Gray, Proc. Amer. Acad. 16: 85. 1880. *T. leptotes* (A. Gray) Osterh., Muhl. 4: 69. 1908, as *lepotes*. Type: Middle Park, Grand Co. (?), Colorado, Jul-Aug. 1864, *Parry s.n.* Holotype, GH! Isotypes, F, MO, NY, PH, UC, US, YU!

Rosulate-pulvinate caespitose perennial herbs from a much-branched, short, woody subteranean caudex arising from a well-developed tap-root, the upper branches of the caudices often clothed with persistent leaf-bases and terminated by tufts of leaves, the plants up to 4 cm high and 10 cm across; leaves linear to oblanceolate or narrowly spathulate, entire, the apex acute, mucronate, moderately strigose-sericeous, especially so on the margins, becoming less so on the blades, often involute, 1-3 (4) cm long, 1.3-2.6 mm wide, the leaf-blades tapering imperceptably to the leaf-base, the anthrocynsis leaf-bases strigose abaxially, slightly less so to glabrous on the adaxial surface; peduncles lacking; involucres campanulate at the base, 0.9-1.4 cm wide, 0.5-1 cm high; phyllaries in 4-7 series, lanceolate to nearly linear, acute at the apex, the margins ciliated and scarious, mostly reddish-purple, glabrous or with a few scattered hairs along the midrib, 3-9 mm long, 0.8-1.4 (1.8) mm wide, the inner ones the longest; ray-florets 13-34; ray-corollas whitish, cream, or pink, glabrous, the rays 6-10 mm long, 1.2- 2mm wide, the tubes 2.5-3 mm long, cream to tan; disk-corollas yellow, sometimes tinged with pink, 3-5 mm long; achenes oblanceolate, compressed, 2-ribbed, those of the rays rarely 3-ribbed, sparsely to moderately pubescent with long, fine, glochidiate hairs; pappus of the ray-corollas of 15-30 plurisetose, barbellate, bristles 3.5-6.5 mm long, sometimes exceedingly reduced in some to less than 1 mm long; pappus of the disk-corollas similar to the ray-corollas only not reduced. $2n = 18$ (Beaman, 1957).

Distribution: Widely-scattered and isolated in the high mountains of extreme southwestern Montana, northwestern Wyoming, and adjacent southeastern Idaho, southward into western Colorado and the extreme northern part of New Mexico, northeastern and central Utah, and westward across central Nevada in the Toiy-

abe and Toquima ranges to the White Mountains of extreme east-central California. Flowering May to August.

REPRESENTATIVE SPECIMENS: Summit Co.: divide between E Fork of the Bear River and Black's Creek, Uinta Mts., 27 Jul 1957, *Beaman & Stone 1446* (MSC); divide between E Fork of the Bear River and Black's Fork, Uinta Mts., 9-13 July 1930, *Goodman & Hitchcock 1517* (CAS, DS, GH in part MO, NY in part, PH, RM, UC). Sanpete Co.: Spring Hollow drainage above the Great Basin Experiment Station, 12 Jun 1948, *Holmgren & Shaw 7640* (CAS, MO, NY, POM, UC, US, UTC).

Townsendia leptotes is a species of wide geographical range and capable of occupying a variety of montane ecological niches. This feature of the species might be appreciated by the phytogeographer and the taxonomist were it not for the fact that this taxon exhibits the greatest amount of variation in the genus. The variation is expressed in terms of almost every extreme, but none of them is subject to any kind of geographical or ecological pattern, and to make matters worst, unduely amounts of variation may be noted in geographical adjacent populations. In Utah, from the data gathered to date, the amount of variation does not seem to be as extensive as found elsewhere. This is due primarily to the small number of known sites where the species occurs in Utah, the almost total apomictic nature of the Utah plants, and the apparent lack of hybridization. Even so, the two major populations of Utah plants do not seem to be too closely related. According to Beaman (1957), the plants from the Uinta Mountains are similar to some populations found in southwestern Colorado and in central Idaho. On the other hand, the plants from the Wasatch Plateau are similar to those found in the high mountins of central Nevada and extreme east-central California. Throughout the range of *T. leptotes* it forms hybrids with *T. exscapa*, but not in Utah as the two do not grow together. Perhaps, it is for this reason that populations of *T. leptotes* are not too difficult in Utah.

7. TOWNSENDIA HOOKERI Beaman

Townsendia hookeri Beaman, Contr. Gray Herb. 183: 95. 1957. Type: Dry hills in Mt. Vernon Canyon, 1730 m elev, Jefferson Co., Colorado 13 Apr 1920, *Clokey 4338*. Holotype, COLO. Isotypes, CAN, CAS, DS, F, GH, MICH, MO, MONTU, NA, PH, POM, RM, UC, US, UTC, WS, WTU!

Densely rosulate-pulvinate caespitose perennial herbs from short, numerous, subterranean, woody caudices arising from a heavily wooded taproot, the caudices densely invested in old persistent leaves and leaf-bases, each caudex branch terminated by a dense tuft of leaves and frequently a flowering head, the plants up to 4 cm high and forming mats up to 10 cm across; leaves linear to narrowly oblanceolate, entire, the apex acute, mucronate, densely strigose-sericeous on both surfaces, involute, 2.5-4 cm long, 1-2 mm wide, the

leaf-blades tapering to the leaf-base, these densely strigose with numerous long white hairs; peduncles lacking, the heads embedded in and surpassed by the leaves; involucres obconical-campanulate, 9-14 mm wide, 9-13 mm high; phyllaries in 5-7 series, linear or nearly so, acute to acuminate at the apex, terminated by a projection of few to numerous long tangled cilia (tufted in some), the marginal ciliate scarious and much shorter, pilose-strigose on the abaxial surface, green below becoming purplish above often along the midvein for some distance downward in most, 5-10 mm long, 0.6-1.2 mm wide, the inner ones the longest; ray-florets 13-34; ray-corollas white on the adaxial surface and cream or occasionally pink on the abaxial surface, glabrous, the rays 6-9 mm long, 1-1.9 mm wide, the tubes 2.5-4 mm long, dark pink to ± brownish; disk-corollas yellow, sometimes tinged with pink or purple, 4.5-6 mm long; achenes oblanceolate, compressed, 2-ribbed, pubescent with long, fine glochidiate hairs, often papillose on the margins, 3.5-4.5 mm long, 1-1.5 mm wide; pappus of the ray-corollas variable, of very short plurisetose bristles 1-1.5 mm long, sometimes both on the same achene; pappus of the disk-corollas of 15-30 plurisetose barbellate bristles 5.5-8.5 mm long and free. 2n= 18 (Beaman, 1957).

DISTRIBUTION: Widely scattered from the southern Yukon southward into central Colorado in the Rocky Mountains, and sporatically elsewhere as into Utah, eastern Montana, Wyoming, and western South Dakota. Flowering from May to July.

SPECIMENS EXAMINED: Carbon Co.: Scofield, 24 Jun 1904, *Jones s.n.* (POM). Daggett Co.: N slope of the Uinta Mts., Jul 1959, *Richens 38* (UTC). Duchesne Co.: benches of the Uintas near Duchesne, 13 May 1908, *Jones s.n.* (POM).

Townsendia hookeri is presently known in the state from only three widely scattered stations. The Hooker Townsendia is closely related to *T. exscapa* and the two can be separated only with some difficulty even in Utah. However, as the two species are geographically separated in Utah, with *T. hookeri* restricted to northeastern Utah and *T. exscapa* known only from central Utah, their distinctiveness is clear at least from a geographical point-of-view. Morphologically the caudices of *T. hookeri* are densely but evenly covered with the matted pubescence of the old leaf-bases so that the stems appear smooth. In *T. exscapa*, the matted pubescence is lacking or nearly so. The leaves of both are similar, but those of *T. hookeri* are decidedly narrower, as are the phyllaries. One easily noted taxonomic feature is the disk-pappus length. The pappus of *T. exscapa* is much longer than the corollas, whereas in the other species the pappus barely exceeds the length of the corollas.

In general the plants of *Townsendia hookeri* are predominently apomictic. According to Beaman (1957), only the plants from the Front Ranges of Colorado and adjacent southeastern Wyoming are sexual. It is likely, therefore, that the similarity between our three known populations is tenuous, and one must be aware of the overall

range of variation of the species in order to associate these scattered populations with a single entity.

8. Townsendia exscapa (Richards.) Porter

Aster? exscapa Richards. in Frankl., J. Bot. App. 748. 1823 *Townsendia sericea* Hook., Fl. Bor.-Am. 2: 16. 1834, a new name for *A. exscapa*. *T. exscapa* (Richards.) Porter, Mem. Torrey Bot. Club 5: 321. 1894. Type: Carleton House, Saskatchewan, Canada, *Richardson s.n.* Holotype, K. Photographs in Larsen (1927) and Beaman (1957).

Townsendia sericea Hook. var. *papposa* A. Gray, Mem. Amer. Acad. 4: 69. 1849. Type: Arid hillsides near Santa Fe, Santa Fe Co., New Mexico, Apr-May 1847, *Fendler 349*. Holotype, GH! Isotypes, NY, PH, UC, US!

Townsendia wilcoxiana Wood, Bull. Torrey Bot. Club 6: 163. 1877. *T. exscapa* var. *wilcoxiana* (Wood) A. Nels. in Coult. & Nels. Man. Bot. Rocky Mts. 510. 1909. Type: Camp Supply, Woodward Co., Oklahoma, Mar 1877, *Wilcox s.n.* Holotype, US!

Townsendia intermedia Rydb. in Britt., Man. Pl. Northeast. U.S. 944. 1901. Type: Praire, Trego Co., Kansas, 1896, *Rich 718*. Holotype, NY! Isotypes, GH, MO, RM, US!

Rosulate and nearly pulvinate perennial herbs with several short, rarely elongated, subterranean, woody caudices from a woody taproot, the caudices glabrous or nearly so, not covered with old leaf-bases, the plants up to 3 cm high and 8 cm across; leaves oblanceolate, often narrowly so, entire, the apex acute, mucronate, thinly strigose on both surfaces, not obviously involute, 2.5-5 cm long, 2-3.5 mm wide, with conspicuous midveins, the leaf-blades tapering to the leaf-bases, these strigose; peduncles lacking; involucres campanulate, 1.5-3 cm wide, 1-1.8 cm high; phyllaries in 4-7 series, linear to narrowly lanceolate, acute at the apex, with ciliated scarious margins and apices, glabrous or nearly so on both surfaces, 4-12 mm long, 1-2.3 mm wide, the inner ones the longest; ray-florets 21-40; ray-corollas white or pinkish, often with a darker pink streak on the abaxial surface, glabrous, the rays 8-15 mm long, 1.2-3 mm wide, the tubes 3-5.5 mm long, whitish; disk-corollas yellow, usually purplish (rarely pinkish) tinged at the apex, 6-10 mm long; achenes oblanceolate, compressed, 2-ribbed, those of the rays rarely 3-ribbed, usually heavily pubescent with long glochidiate hairs, 3.5-6 mm long, 1-2 mm wide; pappus of the ray-corollas of 20-30 slender plurisetose, barbellate bristles, 4-8 (10) mm long; pappus of the disk-corollas of 20-45 similar bristles, only 6-12 mm long. $2n = 18$ (Beaman, 1957).

Distribution: Widespread from southern Canada to northern Mexico, and from extreme eastern Nevada to the Great Plains; infrequently found in south-central Utah at high elevations. Flowering from April to July.

Representative Specimens: Garfield Co.: E slope of Boulder Mts., 22 Jun 1938, *Beck s.n.* (BRY); near Posy Lake, Aquarius Plateau, 1 Jul 1938, *Beck s.n.* (BRY); Bryce Canyon, 19 Jun 1933, *Eastwood & Howell 769*, in part (CAS); Bryce Canyon, 30 Jun 1923, *Rodda s.n.* (CAS); Bryce Canyon, 11 May 1934, *Stone 256* (NY); Wildcat Ranger Station, Aquarius Plateau, 19 May 1956, *Vickery 611* (UT). Wayne Co.: Near Fremont, 5 Apr 1934, *Harrison 7365* (BRY).

Townsendia exscapa, the first species to be described in the genus, is found from southern Canada to northern Mexico, and most frequently on the Great Plains. In Utah, the species is found only in the Bryce Canyon area and on the Aquarius Plateau where it is infrequently encountered. These plants are easily recognized (at least in Utah) by the long pappus of the disk-corollas and by their distribution at high elevations in the southern part of the state. Like *T. montana*, *T. exscapa* is extremely polymorphic, but in our state, the variation is not extensive although our plants are likely totally apomictic in nature.

9. Townsendia florifer (Hook.) A. Gray

Erigeron ?florifer Hook., Fl. Bor.-Am. 2: 20. 1834. *Aplopappus* [sic., now *Haplopappus*] *florifer* (Hook.) Hook. & Arn., Bot. Beechey Voy. 351. 1840. *Stenotus florifer* (Hook.) Torr. & Gray, Fl. N. Am. 2: 238. 1842. *Townsendia florifer* (Hook.) A. Gray, Proc. Amer. Acad. 16: 84. 1880. Type: Priest's Rapids of the Columbia River, Kittitas or Grant cos., Washington *Douglas s.n.* Holotype, K.

Townsendia watsonii A. Gray, Proc. Amer. Acad. 16: 84. 1880. *T. florifer* var. *watsonii* (A. Gray) Cronq., Leafl. West. Bot. 6: 49, 1950. Type: Stansbury Island, Tooele Co., Utah, 1869, *Watson 520*. Holotype, GH! Isotypes, US, YU!

Townsendia scapigera D. C. Eat. in Wats. var. *ambigua* A. Gray, Proc. Amer. Acad. 16: 84. 1880. *T. ambigua* (A. Gray) Rydb., Fl. Rocky Mt. 874, 1067. 1917. Type: Rabbit Valley, near Teasdale, Wayne Co., Utah, 6 Aug 1875, *Ward 523*. Holotype, GH! Isotype, US!

Townsendia florifer (Hook.) A. Gray var. *communis* M. E. Jones, Proc. Cal. Acad. Sci. 5: 697. 1895. Type: Marysvale, Piute Co., Utah, 31 May 1894, *Jones 5323*. Lectotype, POM! Isotypes, F, MO, MSC, US!

Caulescent winter annual or biennial herbs with ascending-suberect, branched, strigose-hirsute stems from a taproot, up to 1.5 dm high; leaves basal and cauline, the basal leaves spathulate, entire, obtuse or acute at the apex, occasionally mucronate, strigose on both surfaces often more densely so above than below, the leaf-blades and petioles 2-5.5 cm long, the leaf-blades 3-8 mm wide, tapering imperceptibly into the petiole, this anthrocynsis at the base, the cauline leaves oblanceolate, spathulate or linear, strigose.

1-4 cm long, 0.7-3.8 mm wide; heads terminating the stems; involucres campanulate, 1.5-3 cm wide, 6.5-13 mm high; phyllaries in 3-4 series, lanceolate, acute, with ciliate or lacerate-ciliated scarious margins, strigose on the outer surface, 4-12 mm long, 1-2.5 mm wide; ray-florets 13-34; ray-corollas white or pinkish, often with a darker pink streak abaxially, frequently glandular on the abaxial surface, the rays 7-12 mm long, 1.5-3 mm wide; disk-corollas yellow, frequently tipped or tinged with pink, 3.3-6 mm long; achenes oblanceolate to narrowly obovate, compressed, 2-ribbed, those of the rays rarely 3-ribbed, densely pubescent with bifurated unequally forked hairs with the prongs not recurved, papillose, 3.3-4.5 mm long, 1-2 mm wide; pappus of the ray-corollas of 20-30 plurisetose, barbellate or ciliate, bristles, 2-6 mm long, or of short squamellae less than 2 mm long; pappus of the disk-corollas of 20-40 bristles similar to those of the rays only 3.5-7.5 mm long and slightly exceeding the length of the disk-corollas. $2n = 18$ (Beaman, 1954).

Distribution: Eastern Washington and Oregon southward across southern Idaho into extreme eastern Nevada and western and south-central Utah mainly on sandy soils. Flowering from April to July.

Representative Specimens: Beaver Co.: Near Frisco, 19 Apr 1930, *Cottam 4636* (BRY, UC). Box Elder Co.: 20 mi N of Lucien, 9 May 1942, *Maguire & Holmgren 21518* (GH, MO, NY, PH, UTC, WS, WTU). Garfield Co.: 10 mi S of Coyote, 29 May 1894, *Jones 5315b* (US). Juab Co.: 2 mi E of Troutcreek, 18 Jun 1933, *Maguire & Becraft 2829* (GH, UTC); Thomas Range, 9 May 1968, *Reveal & Thomas 981* (BRY, US). Millard Co.: Pruess Lake, 2 May 1964, *Frischknecht 166* (BRY); 20 mi S and 11 mi W of Delta, 5 May 1941, *Harrison 10156* (BRY, NA); near Desert Range Experiment Station Headquarters, 11 May 1965, *R. Holmgren 451* (BRY); 37 mi W of Delta, 15 Jun 1933, *Maguire & Becraft 2830* (POM, UC, UTC); Warm Point, 19 Jun 1941, *Maguire 20880* (GH, NY, UTC); E slope of Cricket Mts., 5 Apr 1968, *Welsh 6789* (BRY). Sanpete Co.: N of Gunnison, 1 Jun 1944, *Cottam 9392* (UT); 7 mi W of Fayette, 12 May 1962, *Jensen 539* (UTC). Sevier Co.: Joseph City, *Jones 6379* (MO, POM, US). Tooele Co.: Cedar Mts., 25 Jun 1953, *Flowers s.n.* (UT); Stansbury Island, 16 Jul 1945, *Garrett 8780* (NA, UT); Gold Hill, 6 Jun 1917, *Jones s.n.* (POM); Simpson Buttes, Dugway Valley, 4 May 1952, *Smith s.n.* (UT); near Wendover, 8 Jun 1930, *Van Dyke s.n.* (CAS); Onaqui Mts., near Willow Spring, 15 Apr 1968, Welsh 6876 (BRY). Utah Co.: Goshen, 20 Jul 1928, *Garrett 3955* (UT); Mercur, Jun 1896, *Jones s.n.* (POM).

Townsendia florifer is a sharply defined species in Utah and can be recognized with ease, especially in the sandy parts of western Utah where it is so common. In the field, the suberect stems and often large and showy flowering heads can be spotted without difficulty, although it is often necessary to search among the shrubs and in otherwise protected areas for the plants. It is not known

whether this is due to some ecological factor or to grazing pressures exerted by the numerous winter ranging sheep.

Beaman (1957) reports that *Townsendia florifer* is closely related to and forms hybrids with *T. parryi* D. S. Eat. in Parry, a species found north of Utah. However, in our region, the species is more likely to be confused with *T. scapigera* D. C. Eat. in Wats., an entity not yet known from Utah. The range of *T. scapigera* extends from southeastern California northeastwardly to Elko and White Pine counties in Nevada, but no plants have been seen from Utah. The species is to be expected in Box Elder or Tooele counties, and may be distinguished from *T. florifer* as follows:

A. Plants caespitose biennial or short-lived perennial herbs; heads clearly pedunculated; phyllaries in 3-4 series, strigose or pilose on the outer surface; cauline leaves few. *T. scapigera*

AA. Plants winter annual or biennial herbs; heads terminal on the stems; phyllaries in 3-4 series, strigose on the outer surface; cauline leaves numerous. *T. florifer*

10. Townsendia incana Nutt.

Townsendia incana Nutt., Trans. Am. Phil. Soc. 7; 305. 1840. Type: "On the Black Hills, (an alpine chain toward the sources of the Platte [River].)," possibly from near the Wind River Mts. in Wyoming, collected in late Apr 1834, *Nuttall s.n.* Holotype, BM. Isotypes GH, PH!

Townsendia fremontii Torr. & Gray, Bost. J. Nat. Hist. 5: 106. 1845. Type: Wyoming, probably near the Wind River Mts., [Aug ?] 1842, *Fremont s.n.* Lectotype, GH! selected by Beaman (1957).

Townsendia arizonica A. Gray, Proc. Amer. Acad. 16: 85. 1880. Type: Trumbull, Mohave Co., Arizona, 1877, *Palmer 204.* Lectotype, GH! Isotypes, MO, NY, US!, selected by Beaman (1957).

Townsendia incana Nutt. var. *ambigua* M. E. Jones, Zoe 4: 264, 1893. Type: Thompson Springs, Grand Co., Utah, 7 May 1891, *Jones s.n.* Lectotype, POM!, selected by Larsen (1927).

Townsendi dicersa Osterh., Bull. Torrey Bot. Club 55: 75. 1928. Type: Hills south of Grand Junction, Mesa Co., Colorado, *Osterhout 6116.* Holotype, RM.

Pulvinate or suberect perennial (rarely biennial) herbs from much branched, sometimes subterranean, woody caudices arising from thin to stoutish taproots, the caudices often above ground so as to give the plants a caulescent appearance, these stems conspicuously canescent with dense white strigose hairs, the thin stems sometimes long and much-branched; leaves narrowly spathulate to oblanceolate, entire, the apices acutish, macronate, moderately to densely strigose on both surfaces, occasionally more so above than below, the leaf-blades 15-40 mm long, 1.5-5 mm wide, tapering interseptably

into the pediole; heads mostly terminal on the stems, infrequently pedunculate; involucres campanulate, 8-16 mm wide, 7-11 mm high; phyllaries in 3-4 (rarely 5-) series, mostly lanceolate, the apices acute, with scarious and lacerate-ciliated margins, strigose on the outer surfaces, 3-10 mm long, 1-3.5 mm wide; ray-florets 13-34; ray-corollas mostly white on the adaxial surface and often with an abaxial median pink stripe, or lavender on both surfaces, the rays 6-10 mm long, 1.5-3 mm wide, the tubes 2.5-4 mm long; disk-corollas yellow and often tinged pinkish, 3.5-6 mm long; achenes oblanceolate, compressed, 2-ribbed, pubescent with glochidiate hairs, 2.5-4.5 mm long, 1-1.8 mm wide; pappus of the rays of 15-30 plurisetose, barbellate bristles, 0.3-0.6 mm long, often different lengths on the same achene; pappus of the disk-corollas of 15-35 plurisetose, barbellate bristles, 4-7.5 mm long. 2n= 18 (Beaman, 1954).

Distribution: Central Wyoming south through eastern and southern Utah into western Colorado, northwestern New Mexico, northern Arizona, and southern Nevada. Flowering from (April) May to July (November).

Representative Species: Without definite location: Southern Utah, 1877, *Palmer 204* (US); southern Utah, 1874, *Siler s.n.* (GH); southern Utah, 1872, *Thompson s.n.* (US). Beaver Co.: Milford, 19 Jun 1880, *Jones 1794* (MSC, MO, NY, PH, POM, US, UTC, WS). Carbon Co.: near Price, 2 and 12 May 1927, *Flowers s.n.* (UT): Castle Gate, 22 Sep 1888, *Jones s.n.* (Pom); Sunnyside, 15 Nov 1907, *Jones s.n.* (POM); 3 mi S of Price, 9 May 1940, *Maguire & Maguire 18269* (UTC). Daggett Co.: Hideout Forest Camp, 26 Jul 1959, *Flowers et al. 188* (UT); 12 mi S of Manila, 7 Jul 1938, *Hitchcock et al. 3913* (DS, NA,WTU); near Flaming Gorge, 31 May 1932, *Williams 470* (MO., NY, UTC). Duchesne Co.: 5 mi W of Duchesne, 26 Jul 1957, *Beaman & Stone 1448* (MSC); 18 mi W of Duchesne, 5 Jul 1947, *Ferris 11310-A* (DS); Randelet, 22 May 1908, *Jones s.n.* (POM); 3 mi E of Fruitland, 30 May 1942, *Ripley & Barneby 4659* (NY). Emery Co.: Temple Mt., 1 Jun 1962, *Allman s.n.* (BRY); 3-6 mi N of San Rafael Bridge along Utah Hwy. 24, 30 Apr 1963, *Barnett et al. 34* (BRY); Buckhorn Wash, 13 May 1955, *Flowers s.n.* (UT); Huntington Canyon, 21 Jul 1935, *Garrett 7024* (NA, UT); 20 mi SW of Green River, 15 May 1931, *Harrison 5590* (BRY); 0.5 mi N of San Rafael Bridge, 17 Jun 1948, *Holmgren et al. 7768* (NY, UTC); Woodside, 2 Jul 1898, *Jones s.n.* (MO, POM, US); 20 mi E of Hanksville, 8 May 1940, *Maguire & Maguire 18212* (UTC); Calf Springs Canyon, *Maguire & Maguire 18303* (GH, NY, US, UTC, WS). Garfield Co.: between Henrieville and Upper Valley, 21 Jun 1957, *Cottam 14666* (UT); S of Calf Canyon, 2 Sep 1963, *Cottam 17752* (UT); 10 mi S of Boulder, 11 May 1965, *Cronquist 10076* (BRY, NY, UTC); 8 mi SE of Escalante, 25 Jun 1965, *N. H. Holmgren et al. 2030* (BRY, NY, UTC); 20 mi SE of Escalante, 26 Jun 1965, *N. H. Holmgren 2048* (BRY, NY, UTC); canyons above Tropic, 28 May 1894, *Jones 5312t* (POM); Crescent Creek, Henry Mts., no date, *Stanton 487* (BRY); Bryce Canyon, 9

Jun 1931, *Weight B-3114* (US, UT); Eggnog Spring, Bullfrog Creek, 6 May 1965, *Welsh 4001* (BRY). Grand Co.: 1.4 mi W of Crescent Junction, 14 Jul 1954, *Beaman 804* (GH, MSC, UTC); 3 mi W of Dead Horse Point, 26 May 1950, *Cottam 12118* (UT); 16 mi NW of Moab, 22 May 1961, *Cronquist 9067* (NY, UTC); 16 mi SE of Thompson, 11 Jun 1961, *Cronquist & Holmgren 9247* (NY, UTC); above Courthouse Towers, 16 May 1949, *Harrison 11374* (BRY); Westwater, 28 Jun 1898, *Jones s.n.* (POM); Thompson Springs, 1899, *Purpus 6465* (MO, POM, UC, US); Moab, 1-2 Jul 1911, *Rydberg & Garrett 8444* (NY, UC); ca. 32.5 mi from Moab along the Colorado River, along Utah Hwy. 124, 3 May 1968, *Welsh 6994* (BRY); E end of Castle Valley, 3 May 1968, *Welsh 7009* (BRY). Iron Co.: Cedar Canyon, 9 May 1936, *Cottam 6729* (UT); Cedar City, 1874, *Parry 94* (GH, MO); Cedar City, 11 May 1919, *Tidestrom 9431* (US). Kane Co.: 0.6 mi E of the E entrance to Zion Natl. Park, 20 Jul 1954, *Beaman 827* (GH, MSC); base of Checkerboard Mesa, Zion Natl. Park, 27 Jun 1938, *Boyle 7215* (UC); 4 mi S of Cannonville, 12 May 1965, *Cronquist 10082* (BRY, NY, UTC); 1 mi W of Glen Canyon City, 22 May 1965, *Cronquist 10156* (BRY, NY, UTC); 2 mi NNW of Kanab, 6 Aug 1945, *Hester 1016* (NA); 15 mi NW of Orderville, 15 Jun 1940, *Maguire 18863* (NY); Cockscomb Ridge, 6 May 1966, *Welsh 5345* (BRY). Piute Co.: Marysvale, 1 Jun 1894, *Jones 5455q* (US). Sevier Co.: Near Belknap, 10 June 1900, Stokes s.n. (DS, NY, US); Richfield, 5 Jun 1875, *Ward 176* (GH, MO, PH, US). San Juan Co.: Comb Wash, 5 May 1961, *Cronquist 8965* (NY); Four Corners, 10 Jun 1940, *Cutler 3341* (NA, US); 10 mi SW of Blanding, 8 May 1933, *Harrison 5940* (UC, UTC); Bluff, 12 May 1944, *Holmgren 3183* (NY, UTC); SW of Abajo Mts., 10 Aug 1911, *Rydberg & Garrett 9596* (NY, UT); White Canyon, 17 Aug 1963, *Welsh & Moore 2517* (BRY, NY). Uintah Co.: Ca. 35 mi S of Ouray, Jun 1955, *Bartholomew & Bartholomew s.n.* (GH); 5 mi NW of Whiterock, 28 May 1966, *Brotherson 1024* (BRY); Island Park, 15 May 1933, *Graham 7563* (MO, NA); 3 mi NW of Vernal, 25 Jun 1967, *Higgins 1077* (BRY); 1 mi W of Rainbow, 4 Jun 1965, *N. H. Holmgren et al. 1805* (BRY, NY, UTC-mixed with *T. Strigosa*); 5 mi S of Vernal, 30 May 1950, *Norris* 5 (UTC); 14 miles N of Bonanza, 12 Jun 1968, *Atwood 1547*. Wayne Co.: 8 mi SE of Fruita, 25 May 1940, *Carter 1552* (UC); Torrey, 27 May 1944, *Cottam 1336* (UT); Standing Rock area, Canyonlands Nat'l. Park, 30 May 1964, *Cottam 17783* (UT); 5 mi S of Hanksville, 17 May 1950, *Harrison 11536* (BRY, US); Marvine Laccolite, 23 Jul 1894, *Jones 5663ac* (US); 10 mi S of Fruita, 5 Jun 1953, *McVaugh 14453* (CAS, NY); 12 mi E of Fruita, 1 Jul 1940 *Maguire 19294* (NY); 2 mi W of the jct. of Utah Hwy. 117 and the road S from Torrey, 26 May 1968, *Reveal & Reveal 1046* (BRY, US); 1 mi W of Bicknell, 19 May 1956, *Vickery 607* (UT).

Townsendia incana is our most common member of the genus as well as one of the more polymorphic. It is found in numerous eco-

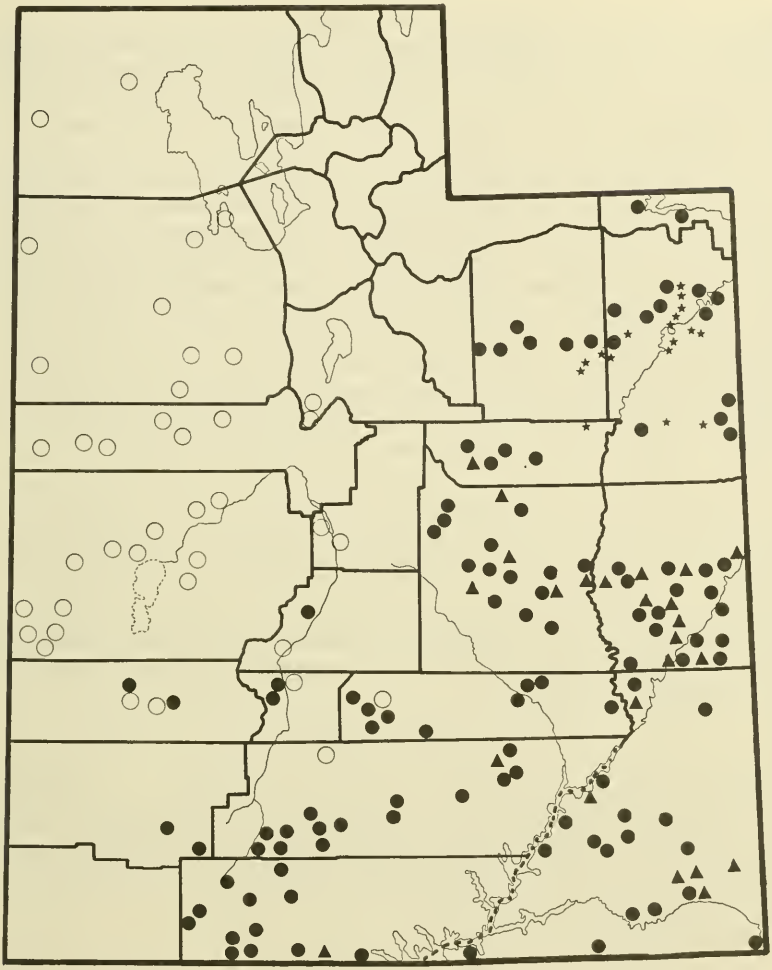

Fig. 2. Distribution of *Townsendia florifer* (open circles); *T. incana* (closed circles); *T. strigosa* (stars); and *T. annua* (triangles).

logical niches ranging from hard clay slopes to loose sandy areas and the edges of steep cliffs. In Utah, the species is found primarily in the eastern and southern portions of the state and thus well isolated from such other species as *T. jonesii* and *T. florifer* with which it can be confused on occasions. In this study, nearly all plants seen from the state appear to be perennial; some from Grand County may be biennial, but they are rare and infrequently collected. The degree of compaction of the plants vary. In San Juan, Kane, Grand, and parts of adjacent counties, the plants tend to be more elongated and less pulvinate. This in part seems to be due to their ecological

niche as most of the plants in this area occur in sandy soils. Some plants from Wayne, Garfield, Kane and other counties in the southwestern part of Utah tend to be more pulvinate. Those of gumbo clay slopes in Wayne Co., for example, tend to verge into *T. jonesii* and *T. aprica* in this respect and care must be taken in identifying specimens from there.

In much of southeastern Utah, the ranges of *Townsendia incana* and *T. annua* overlap. Some plants from San Juan Co. were reported by Beaman (1957) to be intermediate between the two, and apparently some hybridization has led to an overlapping of pappus characteristics. It is equally likely that *T. incana* may also form hybrids with *T. strigosa* in the northeastern part of the state where their ranges come together. Beaman (1957) pointed out the difficulties of differentiating hybrids between the two due to the polymorphic nature of *T. incana*, and no new information has come to light during this study. That the two grow together can be attested by the number of mixed collections from Grand and Uintah counties.

Nevertheless, *Townsendia incana* is rather distinct and easily recognized by the densely pubescent (usually canescent) lower stems. This condition is not seen in either *T. annua* or *T. strigosa*, and except for very depauperate specimens, this feature is easily seen. The problem of hybridization is not acute either for that matter, especially since most of the plants of *T. incana* in Utah are apomictic in Utah, and aside from a few sexual populations in the southeastern part of the state, there is no great concentration of availble genes for any active hybrid swarms.

11. Townsendia strigosa Nutt.

Townsendia strigosa Nutt., Trans. Am. Phil. Soc. 7: 306. 1840. Type: "On the Balck Hills, (or eastern chain of the Rocky Mountains,) near the banks of the Platte [River].", probably near the banks of the Sweetwater River in the vicinity of the Wind River Mts., Wyoming, probably Apr 1834, *Nuttall s.n.* Holotype, BM. Isotypes, GH, PH!

Townsendia incana Nutt., var. *prolixa* M. E. Jones, Contr. West. Bot. 13: 15. 1910. Type: Chepeta Well, Uintah Co., Utah, 23 May 1908, *Jones s.n.* Holotype, POM! Isotype, POM!

Caulescent biennial herbs from a thin taproot with the root-stem junction enlarged, the stems branched at the base with few to many branches, these branched again slightly below the heads in a cymose manner, the plants mostly spreading-suberect, up to 2 dm long; leaves basal and cauline, the basal leaves persistent, oblanceolate to spathulate, entire, the apices acutish, mucronate, lightly to moderately strigose on both surfaces, the leaf-blades 5-15 mm long, 3-6 mm long; achenes oblanceolate, compressed, 2-ribbed, those of the cauline leaves similar to the basal ones only smaller and often clustered immediately below and overtopping the fastigiate heads, the blades up to 2 cm long and 1-3 mm wide, tapering gradually to the

stems, the stems often reddish with the strigose hairs appressed-erect; heads terminal; involucres campanulate. 7-13 mm wide, 5-8 mm high; phyllaries in a 3-4 series, elliptic, ovate or lanceolate, the apices acute, with broad scarious or lacerate-ciliate margins, 3-7 mm long the 1.2-1.9 mm wide, the outer series moderately strigose on the abaxial surface, the longer inner ones only slightly if at al' pubescent near the mid-axis and the apices; ray-florets 13-34; ray-corollas white to pink, occasionally darker at the base or with a longitudinal darker cream to pink streak on the abaxial surface, the rays 6-11 mm long, 1.3-3 mm wide, the tubes 2-3.2 mm long, greenish; disk-corollas yellow, occasionally mottled with pink in some, 3.5-5 mm long; achenes oblanceolate, compressed, 2-ribbed, those of the rays rarely 3-ribbed, moderately pubescent with glochidiate hairs, 3-4 mm long, 0.8-1.3 mm wide; pappus of the rays short, plurisetose, barbellate bristles mostly connate at the base, 0.6-1.2 mm long; pappus of the disk-corollas of 20-35 plurisetose, barbellate bristles, 3-4.8 mm long, mostly equalling or slightly exceeding the length of the disk-corollas.

Distribution: Southwestern Wyoming south into extreme northwestern Colorado and northeastern Utah, often on heavy clay or sandstone soils. Flowering from May to June.

Representative Specimens: Carbon Co.: Nine Mile Canyon, 22 May 1896, *Jones s.n.* (POM). Duchesne Co.: 15 mi SW of Myton, 28 May 1966, *Brotherson 1089* (BRY); 10 mi SE of Myton, 26 May 1933, *Graham 7865* (NA, UC); 6 mi SW of Duchesne, 9 Jun 1940, *Harrison 397H* (BRY, US); Duchesne to Myton, 19 May 1908, *Jones s.n.* (POM); Myton, 20 Ma y1908, *Jones s.n.* (POM). Uintah Co.: 12 mi S of Ouray, 27 May 1966, *Brotherson 1059* (BRY); 5 mi NW of Dinosaur Natl. Mon., 6 May 1933, *Graham 7671* (NA-mixed with *T. incana*); S of the mouth of Sand Wash, 29 May 1933, *Graham 7946* (NA); 1 mi W of Rainbow, 4 Jun 1965, *N. H. Holmgren et. al. 1805* (UTC-mixed with *T. incana*); Randelet, 22 May 1908, *Jones s.n.* (POM); Thorne's Ranch, Big Pack Mt., W of Willow Creek, 15 Jun 1937, *Rollins 1705* (GH, NA, NY).

Townsendia strigosa is restricted to the northeastern corner of Utah where it is locally common, yet only infrequently collected. The plants occur mainly on clay slopes in the Uintah Basin and in better growing season can become a bit weedy, competing with *Eriogonum inflatum* Torr. & Frem. var. *fusiform* (Small) Reveal. The plants do not remain active for long and quickly flower and then become somewhat inconspicuous in the field. Beaman (1957) reports that sheep feed on the plants, and this too must reduce the number of plants somewhat.

This species is closely related to *Townsendia annua* and although the two are allopatric some hybridization likely occured in the past between the two (Beaman, 1957). Superficially, *T. strigosa* resembles some forms of *T. florifer*, but the two differ in types of

hairs on the achenes, and of course as far as Utah is concerned, in their widely separated geographical distributional patterns.

All known plants of this species in Utah are sevual; no apomictic plants are known in the species save one population in Wyoming.

12. Townsendia annua Beaman

Townsendia Annua Beaman, Contr. Gray Herb. 183: 132. 1957. Type: Sandy beds of Cottonwood Wash near Wayland's Ranch, 1.5 mi N of Bluff, San Juan Co., Utah, 19 Apr 1936. *Maguire 13509.* Holotype, GH! Isotypes, CAN, PH, UC, UTC, WTU!

Caulescent annual (rarely biennial ?) herbs with few to many prostrate to ascending stems arising from thin taproots, branching at the base and above, 0.2-1.5 dm high, the stems minutely striated and strigose nearly throughout; leaves basal and cauline, the basal leaves short-lived, drying brown or tan but still ± persistent, oblanceolate to spathulate, entire, the apices mostly acute, occasionally mucronate, lightly strigose on both surfaces but becoming glabrate with age in most, 0.5-1.5 cm long, 1-3 (5) mm wide, the cauline leaves similar to the basal ones only not drying and more persistant, ± evenly distributed along the stems, appearing clustered at the lower nodes in young plants, not surpassing the expanded heads at maturity; heads terminating the leafy stems on inconspicuous peduncles; involucres campanulate, 6-14 mm wide, 4.5-7 mm high, becoming broadly expanded at maturity; phyllaries in 3, rarely 2- or 4- series, elliptic or more commonly obovate to ovate, the apices obtuse to acute or rarely slightly acuminate, the margins scarious and ciliate especially along the upper margins, 2-6 mm long, 1-2 mm wide, the outer ones strigose-pilose, the longer inner ones nearly or entirely glabrous; ray-florets 13-34; ray-corollas white to pink or lavender, often with a darker pink or lavender longitudinal streak on the abaxial surface, the rays 4-8 mm long, 1-2.3 mm wide, glabrous, the tubes 2.5-3 mm long; disk-corollas yellow, sometimes tinged with pink or purple, 2.2-3.5 mm long; achenes oblanceolate to achenes oblanceolate to obovate, compressed, 2-ribbed, those of the rays rarely 3-ribbed, lightly to moderately pubescent with glochidiate hairs, occasionally papillose especially on the achenes of the rays, 1.9-2.6 mm ong, 0.6-1.1 mm wide; pappus of the ray-corollas often of short, plurisetose, barbellate bristles, 0.4-0.8 mm long; pappus of the disk corollas of 15-30 plurisetose, barbellate bristles, 1.8-3 mm long, shorter than the disk tube. $2n = 18$ (Raven et al. 1960).

Distribution: Sandy places from east-central Utah and extreme western Colorado south through eastern Arizona and New Mexico into extreme Texas and extreme northern Mexico. Flowering from April to September.

Representative Specimens: Without definite locality: Denver and Rio Grande Railroad, May 1888. *Shockley s.n.* (UC). Carbon Co.: Price, 15 Oct 1888, *Jones s.n.* (POM). Emery Co.: Green River,

9 May 1890, *Jones s.n.* (MO, MSC, POM, UC, US); Mounds. 9 Jun 1910, *Jones s.n.* (POM). Garfield Co.: Henry Mts., 25 May 1932, *Stanton 1059* (UT). Grand Co.: 5 mi S of Crescent Junction, 15 Jun 1944, *Holmgren & Hansen 3295* (BRY, GH, MO, NY, UC, US, UTC, WS, WTU); Arches Nat'l. Mon., 29 Jun 1948, *Howell 24755* (CAS); Westwater, 20 May 1901, *Jones s.n.* (POM); near Buckhorn Resevoir, 8 Jun 1940, *Maguire 18493* (GH, NY, US, UTC); 4 mi E of Green River, 29 Apr 1965, *Merino 14* (BRY); 12.8 mi SE of Crescent Junction, 4 Jun 1958, *Raven 13075* (NY, UC); near Moab, 1-2 Jul 1911, *Rydberg & Garrett 8441* (NY); 4 mi S of the jct. of Utah Hwy. 24 and U.S. Hwy. 50-6, 3 May 1965, *Welsh 3906* (BRY); Upper Courthouse Wash, Arches Nat'l. Mon., 4 May 1968, *Welsh 7026* (BRY). Kane Co.: 42 mi E of Kanab, 12 May 1953, *Harrison 12079* (BRY). San Juan Co.: 10 mi E of Hite, 15 May 1961, *Cronquist 9026* (NY, UTC); 8 mi N of Bluff, 27 May 1961, *Cronquist 9117* (NY, UTC); Island in the Sky area, 9 Jul 1964, *Moore 236* (BRY); 5 mi W of Hovenweep Nat'l. Mon., 21 Apr 1962, *Wetherell & Finzel 609* (NY).

T. annua from *T. strigosa* is relatively easy. *Townsendia annua* is characterized by the short disk-pappus, achenes, and disk-corollas as well as the deciduous basal leaves. In *T. strigosa*, the disk-pappus is longer than the disk-corolla and has longer achenes, and disk flowers. In addition, the basal leaves of *T. strigosa* are persistent.

Beaman (1957) considered *Townsendia annua* to be strictly an annual. However, in the present, one specimen, (*Merino 14*) is thought to be biennial. It has persistent basal leaves. This specimen likely represents a hybrid between *T. annua* and *T. incana*, but except for this one feature, the plant is typically the annual species. As already noted in the discussion of *T. incana*, most of the populations of this species in Grand Co. are apomictic, and the chances for hybridization are slim. A second possibility is that as this collection of Merino's is on the northern fringe of the range of *T. annua* where adaptation to the biennial habit may be occurring.

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SCIENTIFIC NOTES

NOTES ON THE DISTRIBUTION OF *MACROTUS WATERHOUSII IN SOUTHERN NEVADA*

The California leaf-nosed bat, *Macrotus waterhousii* (=*californicus*), has been previously reported in southern Nevada from only four locations (Hall, Mammals of Nevada, p. 130, 1946; Cockrum and Musgrove, J. Mamm., 45:636-637, 1964). *Macrotus* are usually found in large numbers during the fall and winter when they congregate in selected warm mines. I have made a concerted effort to locate this species during the winter in Clark Co., Nevada with noteworthy results.

Hall (op. cit.) lists *Macrotus* from three locations. At Frenchman's Mine, 7 mi. E Las Vegas, 120 bats of this species were found dead at the bottom of the shaft in 1934. At Jap Ranch, Colorado River, 500 ft, 14 mi. E Searchlight, leaf-nosed bats were found night roosting in abandoned buildings in 1934. In Hemenway Wash, 1600 ft, 14 *Macrotus* were observed in a mine shaft in 1938 (U.S. National Park Service, Boulder City, Nevada). The entrance to Frenchman's Mine has recently been permanently sealed and the other two locations have been under water since the formation of Lakes Mohave and Mead respectively.

Cockrum and Musgrove (op. cit.) found up to 200 *Macrotus* roosting in shafts and tunnels of a mine 4½ mi. N Davis Dam, ¾ mi. W Lake Mohave, 800 ft, Clark Co., Nevada. It is a difficult area to get into and as yet I have been unable to verify the mine location.

On 14 March and 5 April 1964, two students collected a male and female respectively in a mine tunnel 3.8 mi. W Cottonwood Cove Landing, Clark Co., Nevada. These specimens are on deposit in the Biology Museum, University of Nevada, Las Vegas. I examined this tunnel on 16 Nov. 1968 and 2 Jan 1969. Bats were not observed at these times, but the mine is apparently utilized by small numbers of bats at certain times of the year.

On 16 Nov. 1968, four male *Macrotus* were captured at the Rockefeller Mine, SE ¼, Sec. 30, R 64 E, T 27 S, Clark Co., Nevada. At least ten more were observed. The Rockefeller Mine, approximately 4 air line miles from Lake Mohave, is a long, narrow tunnel of extreme warmth and humidity. On 2 Jan. 1969 the mine was visited again and the population estimated to be in excess of 100 bats. On 29 Jan. 1969, 88 *Macrotus* were collected and banded. The difference in numbers observed might be due to a combination of disturbance and periods of warm weather during January. Guano deposits indicate that this mine is frequently utilized by bats. Other mines in the area have been visited during the winter but no bats were observed.

Southern Nevada represents the northern-most extension of the range of *Macrotus*. Prior to 1939 *Macrotus* occurred along the Colorado River and into the Las Vegas Valley. This apparent extension was brought about by man's provision of suitable roosting sites in the form of mines. Ironically, man in recent years has destroyed many suitable roosts and *Macrotus* is now restricted to the southern-most tip of Clark County. Work is now in progress to study populations in this area.

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RICHARDSON'S GROUND SQUIRREL (*SPERMOPHILUS RICHARDSONII*) IN THE LARAMIE BASIN, WYOMING

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Abstract

Richardson's ground squirrel was studied in Laramie Basin, Wyoming (elev. 7,200 ft) from August 1966 to March 1969. Squirrels were active above-ground from early March to late August. Males apparently emerged about two weeks before females. High mid-day summer temperatures resulted in a daily bimodal activity pattern. Mean litter size was 5.9 (range 4 to 9) (N=69 females) based on embryos, placental scar counts and young born in captivity. Juvenile males had a larger home range (1.57 acres) than adults males (0.97 acres). Mean home range size for all squirrels was 0.81 acres. Density ranged from 1 animal per 12 acres in March to 1 per 2.1 acres in June. Based on monthly means, males weighed more than females at all times. The largest male was 536 g and the heaviest female was 473 g. Squirrels exhibited prominent seasonal trends in fatness. Fat reserves were greatest in July (5.30 ± 2.40 g in males and 4.86 ± 2.91 g in females). Spleen weights expressed as a percentage of body weights showed no significant seasonal fluctuation. Adrenal weights peaked in June.

Introduction

The Richardson's ground squirrel (*Spermophilus richardsonii*), a medium sized, diurnal rodent of the west-central and intermontane states has not been mentioned in the literature outside a few scattered species accounts. The purpose of this paper is to report on reproduction, home range, population characteristics, seasonal changes in body weight, fat deposition and spleen and adrenal gland weights of Richardson's ground squirrels in the Laramie Basin of southeastern Wyoming.

Method

Richardson's ground squirrels were studied for over two annual cycles of activity above ground (August, 1966; March-August, 1967-68; and March, 1969) on Hutton Lake National Wildlife Refuge and the surrounding area, Albany Co., Wyoming. Intensive live-trapping (Double-door National live traps) and observations were combined with collection of animals from nearby areas. Traps were moved to new locations within the study area at least weekly. During the sum-

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mer, traps were checked twice daily in an attempt to prevent mortality from high temperatures. Traps were baited with whole wheat. Upon first capture all ground squirrels were toe clipped and dyed with a Nynazol D in a manner similar to that described by Martinsen (1968). Toe clipping was necessary since dye patterns were altered or lost when animals molted. Data on sex, age, and general condition of each ground squirrel were taken at this time. In as much as evidence indicates that nearly all individuals of Richardson's ground squirrel breed in their second year, animals 10 months of age and older were considered adults and those less than 10 months were considered juveniles.

A 100 ft interval grid (1900 ft long and 800 ft wide) was staked on the study area. A white-tailed prairie dog (*Cynomys leucurus*) colony was also located within the grid. With the grid stakes used as reference points, it was possible to accurately plot the activities of Richardson's ground squirrels.

A total of 141 squirrels were examined for changes in reproductive organs associated with the annual reproductive cycle. After position of the testes or vaginal orifice and mammae were examined, species were preserved in AFA. Paired testes were measured (length in mm) and weighed to the nearest 0.01 g on a Mettler balance. Litter size was determined by counts of embryos or placental scars. Uteri were cleared with methyl salicylate. Ten-micron sections of testes were examined microscopically for seasonal changes in spermatogenic activity.

The "point-centered quarter" method devised for grasslands by Dix (1961) was used to sample the vegetation. Both species and lifeform of the vegetation were recorded (DuRietz, 1931).

One method used to determine home range was the greatest distance between points of capture of animals as the diameter of a circle which was considered as the home range area. Another home range method utilized was the minimum home range area plus estimate. In this method a line is drawn around the periphery of the outer points in such a way so as not to exclude areas where the ground squirrels might be expected but not been captured (Bradley, 1967).

Ground squirrels from other nearby populations were collected to supplement data from live trapping and observation. Bodies were fixed in AFA. The retroperitoneal fat, removed and weighed to the nearest one-tenth gram, below the diaphram and to the left of the dorsal aorta was taken as an index to the total amount of stored fat. This method has been used for the eastern woodchuck (*Marmota monax*) by Snyder, Davis and Christian (1961) and on round-tailed (*Spermophilus tereticaudus neglectus*) and Harris antelope (*S. harrisii harrisii*) ground squirrels by Neal (1965). The 141 squirrels used to study reproduction were also used for this portion of the study.

Spleen and adrenal glands were removed, cleaned of excess tissue and weighed to the nearest 0.001 gram. Spleen and adrenal weights

were expressed in per cent of body weight, thus permitting comparison of animals of different sizes.

Description of the Study Area

The study site is approximately 10 miles southwest of Laramie, Albany County, Wyoming, at an elevation of 7,200 ft. This area is in the Laramie Basin and falls within what Cary (1917) called "Transitional Life Zone" and Porter (1962) termed "Interior Grassland Plains." Long (1965) classified the area in the "Cheyenne Plains Faunal Division." The Laramie Basin consists of an arid mountain valley, 35 miles wide and 70 miles long surrounded on three sides by mountains.

The life-form of the vegetation of the study area based on percent of occurrence of each life-form element was 2.5 percent dwarf shrubs, 2.0 percent mid-grasses, 75.5 percent short grasses, 0.5 percent mid-forbs, and 7.5 percent Paramelia lichen. The species were mostly blue grama (*Bouteloua gracilis*), western wheat-grass (*Agropyron smithii*), several species of bluegrass (*Poa* spp.), junegrass (*Koleria cristata*), needlegrass (*Stipa* spp.), and prickly pear (*Opuntia polycantha*). Rabbit brush (*Chrysothamnus* spp.), greasewood (*Sarcobatus vermiculatus*), and saltsage (*Atriplex* spp.) were also present.

The climate is semi-arid. The average temperature based on a 30 year average (1931-1960) is 22.8 F for January (coldest month) and 63.8 F for July (warmest month). This area is characterized by an average growing season of 113 days. Mean annual precipitation is 11.14 inches (Alyea, 1967). Soils of the study site varied from shales to gravels, with the texture of the topsoil being silt loam, loam and fine sandy loam.

Results

Activity Patterns

Daily Activity:—Richardson's ground squirrel was completely diurnal. The pattern of daily activity was dependent upon the prevailing weather. The usual daily routine of an individual squirrel was somewhat as follows: the animal emerged from its burrow generally within an hour after sunrise. The animal sat or stood in, or near its burrow entrance and looked around for a few minutes, and then proceeded to forage within the proximity of the burrow, moving further away as the day lengthened. Many times during the day the squirrel returned to its burrow. During the warmest summer months (June, July, and August) the squirrel returned there until high mid-day temperatures dropped. As the late afternoon approached, the squirrel emerged from its burrow and began foraging again, returning below ground for the night.

As a colony squirrels were active throughout most of the entire day except when local weather restricted above-ground activity. The general pattern of daily activity varied throughout the season. Daily

activity observed early in the season (March, April, and May) was characterized by flat curves, peaking in early afternoon, while curves late in the season (June, July, and August) tended to be bimodal.

Seasonal Activity:—Each year the number of ground squirrels greatly increased above the number in the over-wintering population during early June when young animals appeared above-ground. The mean number of captures for individual animals by monthly periods provided an index to the relative amount of activity throughout the above-ground seasonal activity cycle. The mean number of captures increased from a low in March, to a high in May and then decreased in July (Figure 1). The lower average number of captures in March was probably due to the cold temperatures and frequent occurrence of snow storms. With an increase of warm weather, activity greatly increased to a peak in May.

Hibernation:—Emergence time of the first Richardson ground squirrel varied only slightly from year to year. Squirrels were first noted above-ground on 10 March, 1967; 8 March, 1968; and 13 March, 1969. Animals continued to emerge from hibernation over the following two to three weeks after the emergence of the first animal. All ground squirrels were active by late March. During March,

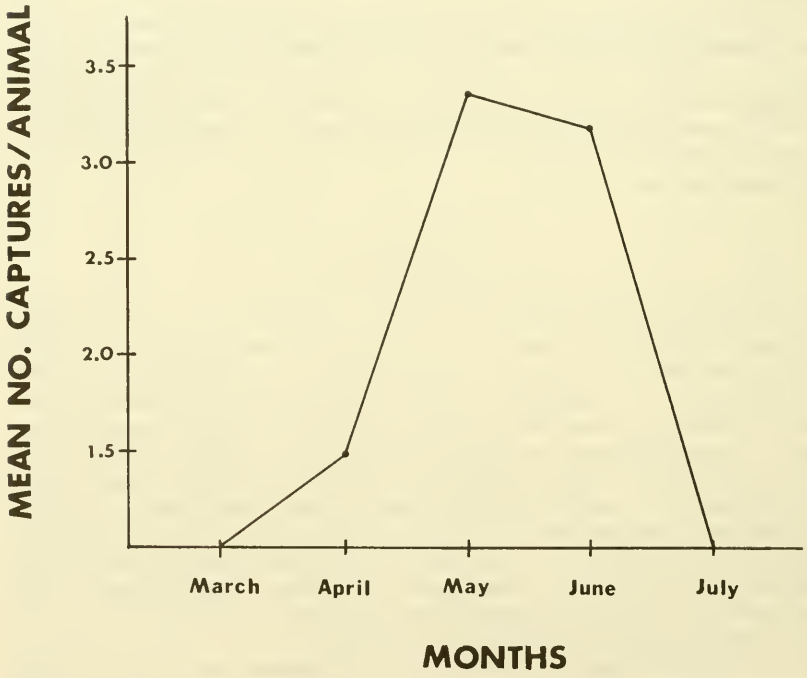

Fig. 1. The average number of captures per individual *Spermophilus richardsonii elegans* for monthly periods.

1968, 15 of the 18 animals collected were males, suggesting that males emerged from hibernation before females.

The number of squirrels active above-ground declined in early July of each year. A sex differential in the time of onset of hibernation did not appear to be marked. Possibly males began hibernating a week or so before females (first week in July for males), and by mid to late July all adults were below ground. By 26 August, 1966, and 25 August, 1967 and 1968, all above-ground activity terminated in all age and sex categories.

Estimates, therefore, can be made of the amounts of time spent in above-ground activity. Colonies in the Laramies Basin were active above-ground for about six months. No single individual was active throughout the full period. Adults were active for about four months and juveniles were active for about three months (June to August).

Activity in Relation to Abiotic Environment:—Large snow storms, which were common in March and April lasting often for several hours. were related to the squirrels disappearing below ground until the snow stopped falling. After these storms the amount of above-ground activity in the fresh snow was reduced.

Light rain showers, lasting only a few minutes, did not seem to affect above-ground activity. Heavy rains and hail storms caused a cessation of all above-ground activity.

Temperature was an important factor which regulated the intensity of the activity of the squirrels above-ground. Field observations showed that the squirrels were largely active within a temperature range of from 25 F-80 F. Captured squirrels began to salivate at about 80 F. Repeated salivation is related to drastic water loss (Bradley, 1967). Squirrels left in traps for a couple of hours at about 85 F died from over-heating and water loss. Approximately 85 F can be considered as the upper-most temperature at which activity above-ground can continue. However, animals were active for short periods of time, 10-15 minutes, at these high temperatures.

Reproduction

Females:—Females passed through a well-defined cycle of seasonal changes in reproductive organs similar to those seen in other *Spermophilus* (McKeever, 1965; Tomich, 1962; Neal, 1965). The sexual reproductive condition of 64 females is given in Table I. Females were considered to be in or near breeding condition if the vulva was open. The beginning of the breeding season in *Spermophilus beldingi* and *S. lateralis* is marked by enlargement of the vulva and the uterus (McKeever, 1965), and a similar cycle of changes also appears in Richardson's ground squirrel. In two squirrels collected on 17 March, their vulvae were closed. The vulva of a squirrel collected on 25 March was beginning to swell, and by 28 March, in 1967 and 1968, all females collected had swollen vulvae. After 15 April in both years, females were collected with vulvae not swollen.

Table I. Reproductive condition of 64 adult female Richardson's ground squirrels collected during two annual above-ground activity cycles (March-July, 1967-68) in the Laramie Basin of Wyoming.

Condition	March	April	May	June	July	Totals
Vulva Open	1	1	0	0	0	2
Vulva Closed	3	21	22	13	3	62
Pregnant	0	15	1	0	0	16
Embryos:						
No.	0	81	5	0	0	86
Mean	0	5.4	5.0	0	0	5.3
Range	0	4-9	5	0	0	4-9
Placental Scars:						
No.	0	23	121	81	18	243
Mean	0	7.0	5.8	6.2	6.0	6.1
Range	0	7-8	4-9	5-8	5-7	4-9
No. without Litters or Scars						
Lactating	4	3	0	0	0	7
No. of Animals	0	4	19	0	0	23
Examined	4	22	22	13	3	64

Therefore, breeding occurred from about 20 March to 15 April each year. Females were pregnant only during April and early May. Adult females entered estrus and bred at approximately the same time.

Litter size *in utero* ranged in number from four to nine, with a mean of 5.3. Placental scars ranged from five to nine (mean 6.1). The mean numbers based on both embryos and placental scar counts in 56 females was 6.06. Five pregnant females, brought into the laboratory, gave birth in late April and early May, 1968, and the average litter size was 6.0 (5-8). Denniston (1957) reported a mean litter size of 7.0 (5-9) for six litters of Richardson's ground squirrels born in captivity. Previously published data and records on litter sizes by Warren (1910), Burnett (1916 and 1920), Day (1923), Howell (1938), Denniston (1957), and Hall and Kelson (1959) on Richardson's ground squirrel showed the number of embryos, placental scars, or young to vary from 4.6 to 8.2. In the present study, the mean litter size was 5.88, determined from embryo counts (N=16), placental scars (N=40), and litters born in captivity (N=5).

Lactation and the presence of placental scars appeared simultaneously. Juveniles were emerging from their nest burrows by June, after which no lactating females were found.

Males:—Comparison of the monthly mean weight of paired testes showed one annual period of peak development. Mean testes weights varied from a high of 1.8 g (1.08-2.65) in March, to 0.73 g (0.34-1.80) in April, and to a low in May of 0.15 g (0.11-0.22). After the decrease, testes gradually increased slightly in weight to 0.16 g in June range (0.14-0.20) and at the onset of hibernation in July they weighed 0.16 g (0.14-0.20). Testicular enlargement before hibernation has been noted in *Spermophilus* by Tomich (1962), McKeever (1963, 1964) and Wells (1935).

Trends in length of the paired testes exhibited a single peak curve similar to testes weight. Lengths of the testes were greatest in March (mean 20.0 mm, 18-22), decreased in length to 13.5 mm (11-20) in April, 8.3 mm (7-9) in May, to a low of 7.6 mm (7-8) in June, and increased to 8.5 mm (8-9) by July.

Testes, considered scrotal if they had descended or could be moved into a scrotal position by external manipulation, had descended in adult males by 17 March, 1968, nine days after squirrels were first emerged from hibernation. The last individual with scrotal testes was noted on 6 April, 1967. The position of the testes of squirrels at the time of emergence from hibernation was not determined, but *Spermophilus beldingi* has scrotal testes and is sexually active at the time of spring emergence (McKeever, 1965). Periods that the testes were scrotal generally coincide with the time when the vulvae were open and swollen (Table I).

Histological changes in the testes follow the same general cycle associated with testes lengths and weights. In mid to late March, when all of the males (N=15) possessed scrotal testes, fully mature spermatozoa were present in the seminiferous tubules. After the breeding season, regression of adult male testes in late March and early April followed the pattern as described by Bakko and Brown (1967), for the white-tailed prairie dog.

Home Ranges

The mean maximal distance traveled by the squirrels in feet was plotted on a graph against the number of successive points of observations or captures (Fig. 2). When a home range had 10 or more points of observation or capture, generally, the size of home range did not increase greatly with additional captures or observations. Data for the nine Richardson's ground squirrels that had at least a minimum of 14 points (the maximum was 49 points) were used to calculate home range.

The mean home range in acres for the nine males was 1.09, calculated by the method of greatest distance between captures. No female was captured 14 times, the minimal number used to establish home range. The home ranges of these males varied from 0.50 to 1.78 acres. Mean home ranges varied between age groups of these nine males. Three males less than 10 months of age had an average home range of 1.57 acres, whereas, two one-year-old males had only 0.97 acres, an area only 62 percent as large as tha tof juvenile males. The four remaining males were adults of unknown ages with an average home range area of 0.91 acres (58 percent of the size of juvenile males).

The same nine male ground squirrels used in determining home range by the greatest distance between captures were also used for calculation of home range size by the method of minimal home range plus an estimate. The mean home range size for these nine animals was 0.53 acres, only 48 percent of the average home range

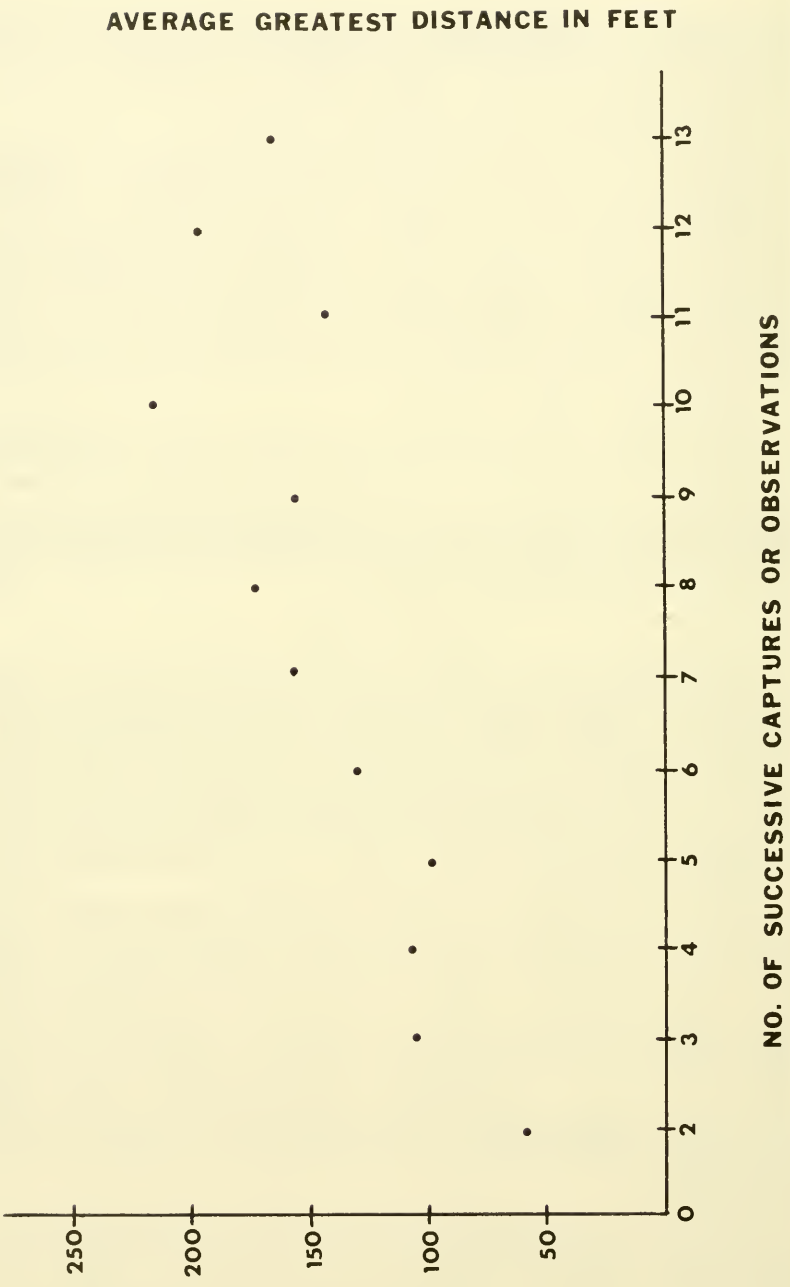

Fig. 2 Average distance of movements of Richardson ground squirrels grouped by successive captures.

Table II. Seasonal changes in the body weights of *Spermophilus richardsonii elegans* in grams

	Adult Males				Adult Females			
Period[1]	No.	Mean	S	Range	No.	Mean	S	Range
March	15	279	±53.6	210-390	3	203	±32.1	180-240
April	14	266	±40.8	230-350	21	247	±69.2	100-360
May	20	308	±60.9	250-460	22	287	±39.5	211-347
June	16	394	±69.9	292-536	12	345	±51.0	250-437
July	3	400	±20.0	380-420	2	320	±22.3	300-330
Total	68				60			

1. No adult ground squirrels were observed above-ground before 8 March (1968) or after late July 1967 and 1968. They were presumed to be below ground hibernating.

area determined by the greatest distance between capture methods. Home ranges varied from 0.10 to 1.21 acres. Home range determined by this method reveals irregular areas in which the animals were generally known to occur. Age differences were also noted in home range areas calculated by this method. Juvenile males occupied 0.78 acres, whereas, one-year-old males averaged 0.36 acres (46 percent of that of juveniles) and other males (adults age unknown) averaged 0.52 acres, only 67 percent of that of juvenile males.

An average for all males of the mean home range areas in acres determined by both methods showed a home range size of 0.81 acres. Generally, juvenile males had a much larger home range area than did adult males. Data from animals caught in both 1967 and 1968 showed that generally the home range of individuals tended to remain in the same geographic area from year to year.

Transplants and Homing

Four transplants were made. In early April, one male and one female were captured in an area adjacent to the study site and were transplanted ¼ mile away from their points of capture. The female returned the next day, and the male was never seen again. Two males of undetermined age were introduced into the study colony in late April. One of these disappeared from its point of release within 3 days after it was transplanted. The other was captured and observed a total of 28 times over a 3 month period and apparently became established in the area to which it was released.

Population Characteristics

Numbers and Density.—A total of 28 squirrels were captured and marked on the study colony. An additional 141 were collected from adjacent areas. Animals captured on the study colony represented almost 5,000 trap-days.

The number of ground squirrels per acre was used as a measure of density (Blair, 1951). Only resident animals as defined by Mc-

Carley (1958) were used in the calculation of density. Density figures ranged from one animal per 12 acres in March to one animal per 2.1 acres in June.

Mortality.—Twelve ground squirrels were marked by July, 1967; eight (66.6 percent) were still present on the study area in April, 1968; and six (50 percent) were there in July, 1968. Predation (by badgers, eagles, and hawks) and live-trapping procedures caused five deaths. Long-tailed weasels, which were abundant in the area, may have accounted for some mortality. Mortality, probably, is highest during the over-wintering dormancy.

Sex ratios.—One hundred and thirty-five squirrels were used to calculate sex ratios, and of these 54 percent were males. Figure 3 shows the sex ratio by months throughout the seasonal activity cycle. During the first and last month (March and July) of the seasonal activity cycle, sex ratios departed greatly from a 1:1 ratio. This was probably due to a differential time of arousal and onset of hibernation between the sexes.

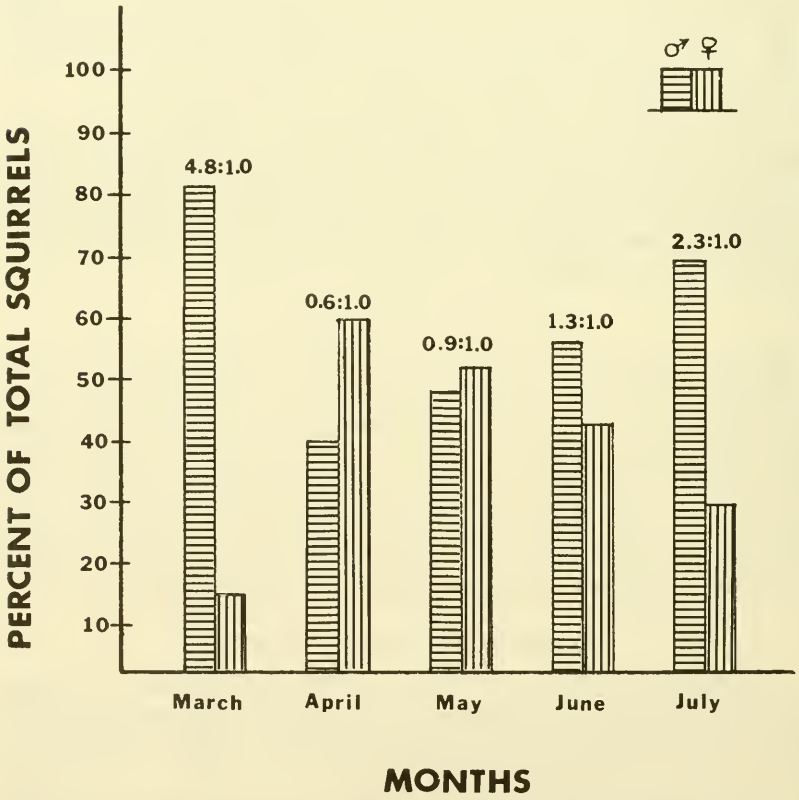

Fig. 3. Sex ratios of *Spermophilus richardsonii elegans* by monthly periods.

Seasonal Body Weight Changes

In 1968, adult males emerged from hibernation approximately two weeks before adult females. Based on monthly means, adult females generally weighed about 20 percent less than adult males of the same period throughout the seasonal activity cycle (Table II). The largest male Richardson ground squirrel weighed 536 g, and the next four largest males weighed 470, 460, 420, and 400 g. The heaviest female weighed 437 g, and the four next largest ones weighed 411, 392, 379, 370 g. A male rarely weighed more than 380 g, or a female more than 340 g. The smallest adult male weighed 210 g, whereas, the smallest female weighed 100 g. Both of these animals were collected shortly after they emerged from hibernation.

Seasonal Changes in Fat Deposition

There is wide variation in the body weights of Richardson's ground squirrel because of differences in age and growth rates of the young and also because adult body sizes of both sexes is highly variable: the basic body unit sustains a remarkable seasonal cycle of fat deposition and utilization. Any study of body mass must consider stores of fat (Tomich, 1962).

Upon emergence from hibernation in March all specimens possessed some fat reserve. During the following two to three months, males and females utilized their fat reserve (Table III). Based on monthly means, males reached a low in fat reserve in April and females in May. Males at first appearance above-ground possessed a larger mean fat reserve than did females (Table III). By July (hibernation) females possessed larger quantities of fat than males.

Males during March possessed a mean fat depot in grams of 5.17 ± 2.63 (0.5-10.4). and this diminished to a low of 0.15 ± 0.34 (0.0-1.1) in April. In May, the mean fat depot increased to 0.41 ± 0.55 (0.0-1.6), by June, it was 2.71 ± 0.94 (2.0-3.8) and was at its largest in July, when it was 5.30 ± 2.40 (2.6-7.2).

In females, the mean fat depot was 3.50 ± 2.40 (0.8-5.3). This fat depot decreased to 0.18 ± 0.34 (0.0-1.0) in April and then rose to 0.45 ± 0.17 (0.0-0.5) in May, then jumped to 4.38 ± 4.25 g (.02-8.7) in June, and rose to 4.86 ± 2.91 (1.8-7.6) in July.

Table III. Seasonal changes in the weight of the left abdominal fat depot of *Spermophilus richardsonii elegans* expressed as a percentage of body weight.

	Adult Males				Adult Females			
Period	No.	Mean	S.	Range	No.	Mean	S.	Range
March	14	1.94	±.87	.32-3.47	3	1.71	±1.20	.43-2.50
April	9	.30	±.23	.13- .46	13	.41	± .27	.13- .67
May	9	.34	±.11	.22- .41	11	.18	± .04	.15- .21
June	3	.82	±.22	.68-1.07	3	1.27	±1.33	.06-2.69
July	3	1.34	±.63	.62-1.80	3	1.54	± .99	.55-2.53
Total	38				33			

The general pattern of fat deposition is similar to that described by Hamilton (1934) for the eastern marmot, as follows: first, fat is laid down in the inguinal region; it then spreads out to cover the rump it also commences on the shoulders, the two regions may be joined finally as a single layer. The region of the heaviest coating lies over the hind legs and the rump. Coincidentally, a rapid proliferation of fat about the genital organs and the kidneys occur. Immediately prior to hibernation, the internal organs caudal to the diaphragm are concealed in a white mantle of fat.

Seasonal Changes in Spleen Weights

Spleen weights expressed as a percentage of body weights showed no large fluctuation (Table IV). In March, the mean splenic weight in grams for males was 0.76 ± 0.24 (0.31-1.27). The mean weight in April was 0.96 ± 0.19 g (0.70-1.30), and in May it was 1.21 ± 0.49 (0.84-0.23). In June, it dropped to 1.10 ± 0.56 g (0.30-1.52).

In females, the mean splenic weight for March was 0.63 ± 0.33 (0.36-1.00), in April, 1.10 ± 0.19 (0.71-1.19), in May, 1.26 ± 0.32 g (0.62-1.62), and was at a peak in June, when it was 1.28 ± 0.38 (0.83-1.57).

Table IV. Seasonal changes in splenic weights expressed as a percentage of body weight in relation to sex in *Spermophilus richardsonii elegans.*

	Adult Males				Adult Females			
Period	No.	Mean	S.	Range	No.	Mean	S.	Range
March	15	.28	± .085	.12-.38	3	.30	± .111	.20-.42
April	8	.35	± .103	.23-.54	12	.43	± .180	.21-.71
May	9	.45	± .182	.22-.68	11	.40	± .138	.20-.59
June	4	.31	± .133	.08-.52	3	.36	± .102	.24-.43
July	....	....	....	.....	....	....	....	.....
Totals	46				39			

Seasonal Changes in Adrenal Weights

Both male and female Richardson ground squirrels reached a peak in adrenal weights, expressed as a percentage of body weight, in June, shortly before entering hibernation. At this time (June) adrenal weights were at least twice as great as at other times of the above-ground activity cycle for which sufficient data exists (Table V).

Shortly after emerging from hibernation the mean adrenal weight in grams of the males for March was 0.058 ± 0.020 (range 0.03-0.10 g), in April the mean was slightly greater being 0.064 ± 0.026 (range 0.04-0.12). The mean value dropped in May to 0.040 ± 0.019 (range 0.02-0.06) and increased sharply in June to 0.144 ± 0.047 (range 0.09-0.20).

In females, the mean adrenal weight for March was 0.047 ± 0.011 (range 0.04-0.06 g). The mean in April was 0.038 ± 0.013

Table V. Seasonal changes in adrenal weights expressed as a percentage of body weight in relation to sex in *Spermophilus richardsonii elegans.*

Period	Adult Males No.	Mean	S.	Range	Adult Females No.	Mean	S.	Range
March	13	.02	± .008	.01-.04	3	.02	± .007	.02-.03
May	7	.01	± .040	.01-.05	10	.02	± .009	.01-.04
April	4	.03	± .009	.01-.02	6	.02	± .019	.01-.03
June	4	.04	± .005	.03-.05	3	.05	± .020	.03-.07
July	1	.02	....	.....	....	....	....	.....
Totals	28				22			

(range 0.02-0.06), increasing somewhat by May to 0.059-0.015 (range 0.04-0.08), and was 0.169 ± 0.051 (range 0.11-0.22) in June.

Discussion

Apparently the male Richardson's ground squirrel emerges from hibernation a week or so before the female does. This differential pattern in arousal time between the sexes of ground squirrels of the same species has been noted by Scheffer (1941) in *S. townsendi* and *S. washington,* and by Manville (1959) in *S. columbianus.*

Davis (1939) observed that on 21 July, Richardson's ground squirrel in Idaho, was active from sunup to almost 9 AM at which time it returned to the burrow and then reappeared in the late afternoon. Seton (1929) noted that when temperatures reached near 85 F, Richardson ground squirrels disappeared below ground in their burrows. This was also the general pattern of daily activity observed in Richardson's ground squirrel during the summer months in the Laramie Basin of Wyoming.

Day (1923) reported that Richardson's ground squirrel first appeared above ground in May or early June in Wyoming, and Warren (1910) noted the first appearance around 1 April, in Colorado. Results of this study showed that ground squirrels emerged from hibernation about two months earlier than the dates reported by Day (1923).

Adults went into hibernation during July, and young disappeared by late August in the Laramie Basin of Wyoming. In Nevada, Borell and Ellis (1934) reported that the Richardson's ground squirrel was active in late August. Tanner (1927), in Utah, stated that by 8 August about 90 percent of Richardson's ground squirrels had gone into "aestivation" and those remaining out were young of the year.

The onset of hibernation in Richardson's ground squirrel during this study was related to large accumulated fat depots. In the thirteen-lined ground squirrel, after fat layers reached a maximum, hibernation occurred regardless of environmental stimuli (McCarley, 1966).

Published home range information on ground squirrels is limited. Home range size for Richardson's ground squirrel averaged 0.81 acres. Evans and Holdenreid (1943) reported a home range of 0.36

acres for males and 0.59 acres for females of *S. beecheyi*. *S mohavensis*, a desert ground squirrel, was reported to have a home range in excess of 3 acres by Burt (1930). Hawbecker (1958) found a home range of about 11 acres for *S. nelsoni*. Home range of *S. leucurus* has been given as 11.7 to 19.5 acres by Jorgensen and Hayward (1965) and 14.9 to 20.6 acres by Bradley (1967). McCarley (1966) found a home range size of 11.7 $\pm$ 2.1 acres for males and 3.5 $\pm$ 0.5 acres for females of *S. tridecemlineatus*.

The sex ratio of males to females found in Richardson ground squirrels during this study was 1.0:1.1. Several other studies on ground squirrels have shown some deviation from 1.0:1.0 sex ratios. McCarley (1966) reported a 1.0:2.8 and believed these to be somewhere near the actual sex ratio in *S. tridecemlineatus*. A 0.7:1.0 ratio was found by Mayer (1953) in *S. barrowensis*.

Both adult males and adult females steadily gained weight from a low body weight at the time of spring emergence (March) until their entrance into hibernation (July), except that males in April, showed a slight drop in body weight. Neal (1965) found that male *S. tereticaudus*, a hibernator, maintained its body weight during the first three months (January, February, and March) after appearance above-ground, then for the next two months, April and May, the weight increased and then dropped for the month of June, increased again in July and August and finally, in September prior to hibernation dropped again. Female, *S. tereticaudus* lost weight after emerging from hibernation during the first two months, then their weight increased steadily until September except for a drop from May to June attributed to the stress of nursing and caring for young.

Richardson's ground squirrel exhibit seasonal trends of fat deposition. This general pattern is evident in many hibernating squirrels (*S. beecheyi*, Tomich, 1962; *S. tereticaudus*, Neal, 1965; *Marmota monax*, Snyder, Davis, and Christian, 1961; and *Cynomys leucurus*, Clark, 1969; unpublished).

The process of fat deposition in the Richardson's ground squirrel seems similar to that described by Hamilton (1934) and Snyder, Davis, and Christian (1961) for the eastern woodchuck.

Several investigators have studied splenic and adrenal hypertrophy, especially as possible indicators of various kinds of stress (Chitty, 1960; Christian, 1963). In Richardson's ground squirrel no clear-cut distinction can be made between the sexes as far as splenic hypertrophy is concerned. Data seem to show that splenic weights are highly variable. No splenic hypertrophy was noted during the breeding season, during pregnancy, or lactation. Davis, Beer, and Cook (1961) noted that spleen size increased up to 50 percent in late pregnancy in *Peromyscus*. A similar phenomena was not encountered in Richardson's ground squirrel. If adrenal size reflects stress in a direct manner then males should undergo some stress during the breeding season, while females are subjected to about the same amount of environmental pressure before, during and after the breed-

ing season. In the thirteen-lined ground squirrel, there is a significant increase in adrenal weight during the breeding season (Zalensky, 1934). Anthony (1953) could find no seasonal trend in his analysis of adrenal weights in the male black-tailed prairie dog (*Cynomys ludovicianus.*).

The increase in adrenal weights in adult females in June may be an indication of the effect felt as a result of the young prior to their initial emergence from the nest where crowding might exist. In males possibly this crowding was not felt until young were aboveground and fully active during late June and early July. Behavioral responses to crowding might result in dispersal in young. In contrast with the round-tailed ground squirrel, Lyman et al. (1955) and Neal (1965), the Richardson's ground squirrel increased its adrenal weight immediately prior to hibernation.

Acknowledgments

I would like to acknowledge Dr. C. A. Long, Mr. M. H. Maxell, and the late Dr. R. R. Lechleitner for reviewing the manuscript.

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A TAXONOMIC COMPARISON OF *UTA STANSBURIANA* OF THE GREAT BASIN AND THE UPPER COLORADO RIVER BASIN IN UTAH, WITH A DESCRIPTION OF A NEW SUBSPECIES

Lloyd E. Pack, Jr. and Wilmer W. Tanner[1]

One of the most common lizards throughout the western United States and the state of Utah is the side-blotched lizard, *Uta stansburiana*. This species and the genus was first described in 1852 by Baird and Girard from the specimens obtained by the Stansbury expedition to the Great Salt Lake Valley in 1849. The type locality was designated as the Valley of Great Salt Lake, Utah. Its range was subsequently found to extend from Texas to California, and from Washington and Idaho to Mexico. Three subspecies of this lizard are of concern to us and currently recognized in the literature (Smith, 1946: Schmidt, 1953; Stebbins, 1966; and Tinkle, 1969) *Uta stansburiana stansburiana* Baird and Girard, found in eastern Washington, eastern Oregon, southern Idaho, northeastern California, most of Nevada, all of Utah except the southwestern corner, western Wyoming, western Colorado, northeastern corner of Arizona, and northwestern corner of New Mexico; *Uta stansburiana stejnegeri* Schmidt in southeastern California, southern Nevada, southwestern Utah, Arizona, New Mexico, western Texas, and northwestern Mexico; and *Uta stansburiana hesperis* Richardson restricted to southwestern California, and northwestern Baja California. Several authors (Van Denburgh, 1922; Woodbury, 1931; Smith, 1946; and Tanner and Jorgensen, 1963) have suggested problems concerning this assignment of names and ranges, and pointed out the need for additional study.

The subspecies *U. s. stansburiana*, which is the principle subject of this study, occurs in two major geographic areas: the Great Basin, and the Upper Colorado River Basin. These basins have been separated from each other by high mountains and plateaus since before the last ice age. Such isolation might result in the development of differences in the basic characteristics of these two populations, even if the habitats of both basins were essentially identical. Because there are differences in both the edaphic and biotic factors between these basins we would expect differentiating selective pressures to be operating. Given enough time, these selective pressures would produce significant differences between the two lizard populations. One factor of special importance is the presence of a significantly higher amount of ground radioactivity in the Upper Colorado River Basin (Tanner, 1965).

It has been shown that the following species of reptiles have populations in the Upper Colorado River Basin that are subspecific-

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ally distinct from adjacent populations in the Great Basin: *Crotaphytus collaris*, *Crotaphytus wislizeni*, *Sceloporus magister*, *Xantusia vigilis*, *Sauromalus obesus*, *Cnemidophorus tigris*, *Hypsiglena torquata*, and *Crotalus viridis*.

A search of the literature failed to uncover a comparative taxonomic study to determine the degree or signifiance of morphological differences that may exist between these two *Uta* populations. With the above considerations in mind a study was begun which included an examination and comparison of the external anatomical characteristics of the populations occurring primarily in the Bonneville Basin of the Great Basin and the Upper Colorado River Basin. A comparison of these with *Uta* from several adjoining as well as distant populations was also made.

The first separation of *Uta stansburiana* into subspecies was that of Ruthven (1913). His work consisted of a description of *U. s. nevadensis*, and did not include an analysis of the total population of the species. The first real attempt to understand the taxonomy of the species was undertaken by Richardson (1915) and involved the following: a recognitiion of the Great Basin population as *U. s. stansburiana;* a recognition of the southern population (SE Calif., Ariz., N. Mex., Texas and Mexico) as *U. s. elegans* (described by Yarrow in 1882 as *Uta elegans*); and the naming of a new subspecies *U. s. hesperis* from southern coastal California. The separation by Richardson was based upon four characteristics: overall size (total length, snout-vent length, tail length, and length of the hind leg), number of dorsal scales in a line between the interparietal plate and a point above the posterior surface of the thighs, relative carination of dorsal scales and the number of femoral pores. In 1946 Smith added the number of rows of postrostrals, prefrontal contact on the middorsal line, and distinct dorsolateral stripes on the females as distinguishing characteristics between those subspecies; but, in agreement with the checklists of Stejneger and Barbour (1943), he used the name *U. s. stejnegeri* for the lizards which Richardson called *U. s. elegans*. The latter subspecies is now restricted to Baja California. Tinkle (1969) extends the range of *s. elegans* into south ern and coastal California and does not recognize *s. hesperis*.

For this study we analyzed all of the above characters (with some modifications) and added several others. The first additional characters were selected for the ease with which they could be checked and the possibility that they might lead to other previously unreported characters. Photographs were made, which suggested several possible variations in scalation of the head. Finally, from field observations, variations in coloration and pattern were selected as possibly significant characters. The characteristics and the methods by which they were determined is as follows:

Dorsal scales - from interparietal to level of posterior surface of thighs (Fig. 1).

Ventral scales - first enlarged scale behind gular fold to last enlarged scale at vent (Figs. 2 and3).

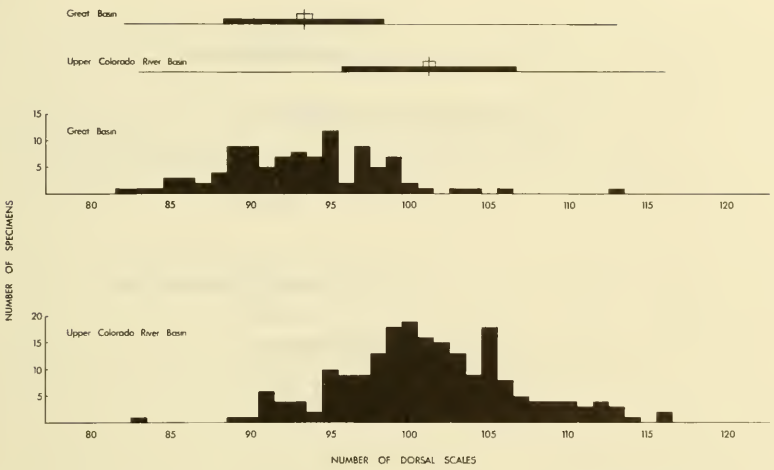

Figure 1. The number of dorsal scales in the two major Utah population of *Uta stansburiana*. The ranges, means, standard deviations, and standard errors of each are shown at the top of the figure. Horizontal black lines indicate range of variation; the dark rectanble outlines one standard deviation on either side of the mean; the vertical line is the mean.

Femoral pores - total number of pores on both hind legs (Fig. 4).

Supralabials and infralabials - counted from the rostral or mental respectively to a point directly below the center of the eye (Fig. 5).

Postrostrals - Number of scales separating the anterior internasals and rostral. If either or both of the anterior internasals were separated from the rostral by two scales it was recorded as two rows; if they were both separated from the rostral by a single scale it was recorded as one row. This was in contrast to Smith's (1946) definition, requiring both anterior internasals to be separated from the rostral by two postrostrals and was chosen because his work had previously shown that the separation of the rostral from both anterior internasals by two scales was an unusual condition except in the *Uta* of coastal California.

Frontoparietals - scales bounded anteriorly by the frontals, posteriorly by the interparietal, and laterally by the circumorbitals and parietals.

Scales between interparietal and supraoculars - number of scales along a line from the parietal eye to the supraoculars at an angle of 45° to the midline of the body, usually including a single frontoparietal and one to three circumorbitals. Right and left sides were added together.

Occipitals - number of occipital scales touching the posterior margin of the interparietal (Fig. 6).

Snout-vent length - tip of snout to vent measured in millimeters.

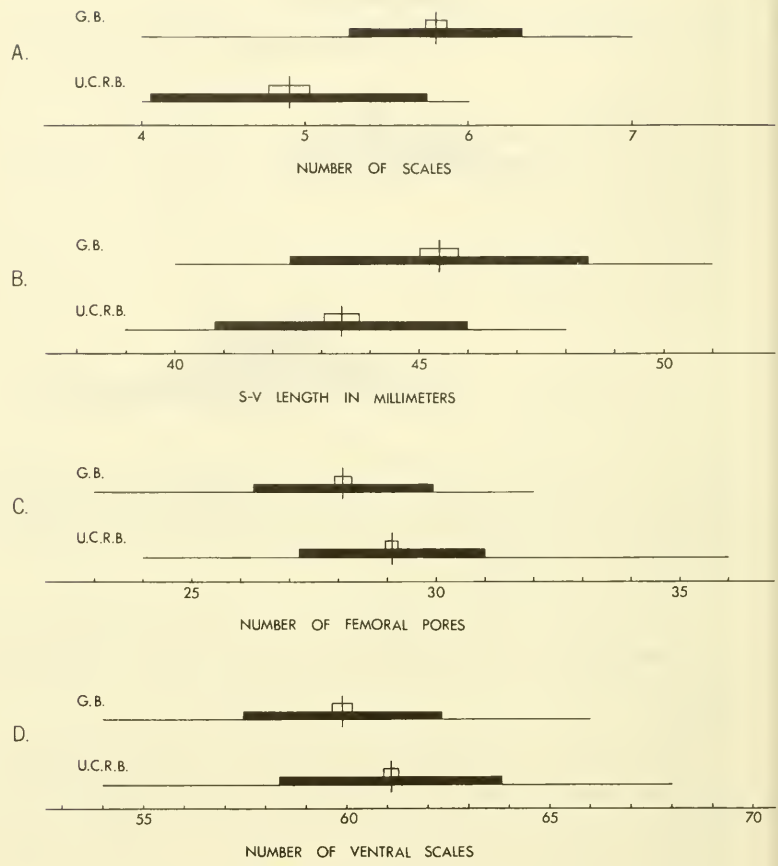

Figure 2. (A) the number of scales on a line between the interparietal and supraoculars; (B) the snout-vent length in millimeters; (C) the total number of femoral pores; and (D) the number of ventral scales in *Uta stansburiana* of the Great Basin and Upper Colorado River Basin in Utah. Symbols as in Fig. 2.

Rostral shape - height and width of rostral, and ratio of height to width.

Frontonasal length - ratio of the average length of the two lateral frontonasals to the length of the median frontonasal (Fig. 7).

Internasal contact with lateral frontonasals - if scales were in contact on one or both sides, the condition was designated as "yes." If not in contact on either side, as "no," and the distance separating them was measured (Fig. 8).

Prefrontals - four conditions were observed in the prefrontals; two prefrontal scales in contact on the midline; two prefrontals separated by the frontal and median frontonasal (which contact each

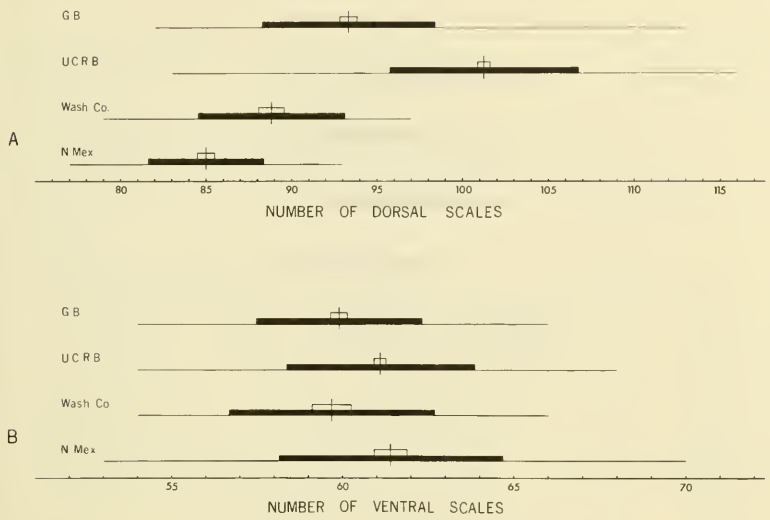

Figure 3. (A) the number of dorsal scales, and (B) the number of ventral scales in four populations of *Uta stansburiana* (Great Basin in Utah; Upper Colorado River Basin; Washington County, Utah; and Dona Ana County, New Mexico). Symbols as in Fig. 1.

other); two prefrontals separted by a small median prefrontal, also separating the frontal and median frontonasal; (or any of several abnormal arrangements or shapes of the prefrontals or adjacent scales.) Each specimen had one of these patterns (Fig. 4).

Rostral - shape of upper edge - upper edge of rostral definitely concave or approximately straight on both sides. Characters were noted as curved or straight (Fig. 8).

Internasal size - anterior internasals approximately the same size as the posterior internasals or considerably larger (Fig. 9).

Parietal size - parietals vary in size from the same size as the supratemporals and frontoparietals to several times larger. If their size (measured as longest distance across) was not more than $1\frac{1}{2}$ times larger, they were considered as the same size, however, if greater than $1\frac{1}{2}$ times they were listed as larger (Fig. 9).

Posterior margin of interparietal - posterior was determined to be straight, concave (often with a single scale set in the concavity), or convex.

Throat or gular color - specimens were checked as having no blue, a light or pale blue, or an intense blue color on the throat. In addition, the throat was checked for no gray, less than $\frac{1}{2}$ gray, or more than $\frac{1}{2}$ gray.

Back pattern - the presence or absence of a pattern of light or dark markings on the back, other than the bright blue spotting common in males of this species (Fig. 10).

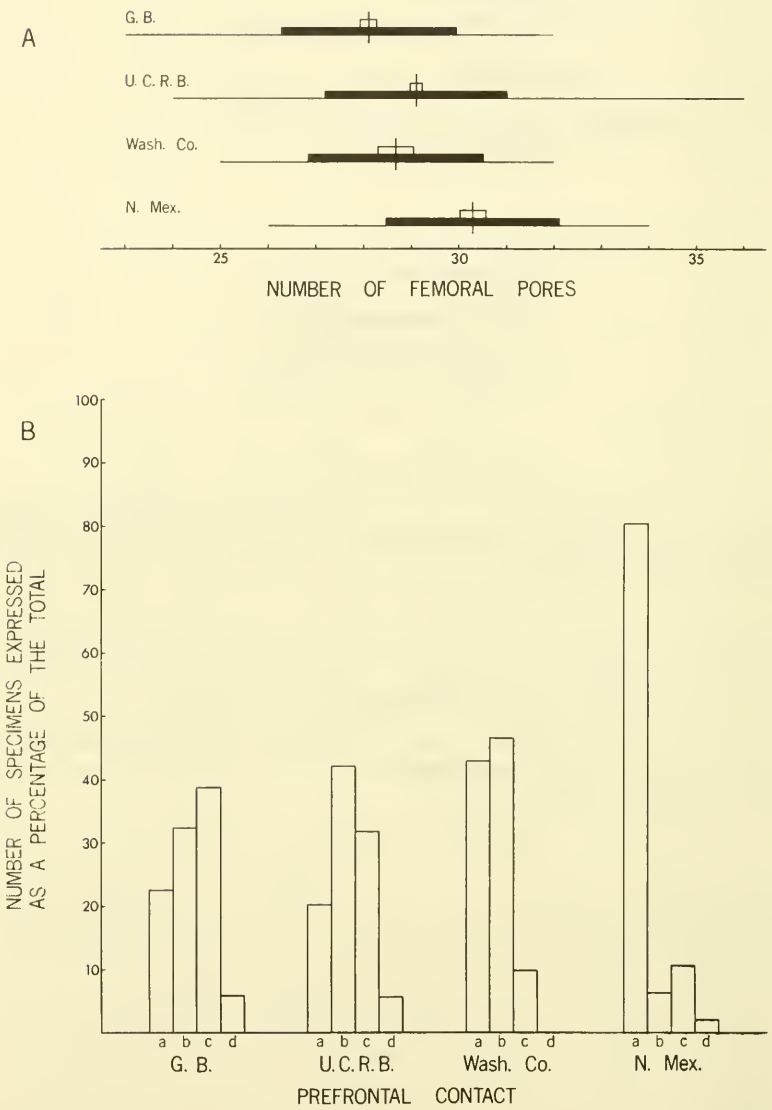

Figure 4. (A) The total number of femoral pores on both hind legs in four populations of *Uta stansburiana* (Great Basin in Utah; Upper Colorado River Basin; Washington County, Utah; and Dona Ana County, New Mexico), and (B) a comparison of the same four populations regarding the four possible conditions of the prefrontals: a) prefrontals in contact at the midline, b) two prefrontals separated by a median prefrontal, c) prefrontals separated by the median frontonasal and frontal which contact each other, and d) abnormal arrangement or shape of the prefrontals and adjacent scales. Symbols as in Fig. 1.

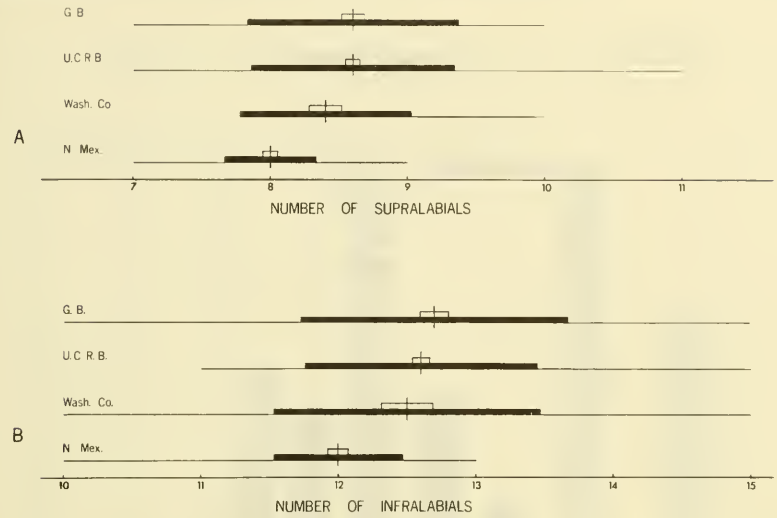

Figure 5. (A) the total number of supralabials on both sides of the head from the rostral to a point below the middle of the eye, and (B) the total number of infralabials on both sides of the head from the mental to a point below the middle of the eye in four populations of *Uta stansburiana* (Great Basin in Utah; Upper Colorado River Basin; Washington County, Utah; and Dona Ana County, New Mexico). Symbols as in Fig. 1.

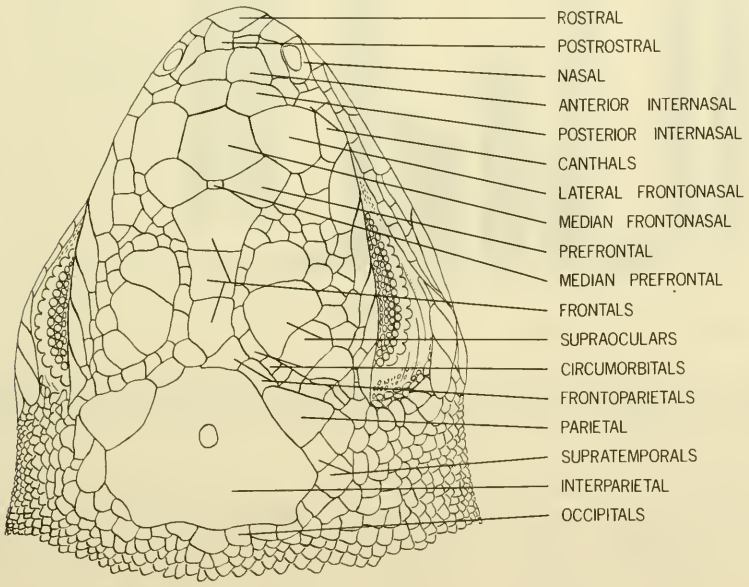

Figure 6. Illustration of the dorsal head scales of *Uta stansburiana* modified from BYU 22985. See Fig. 13.

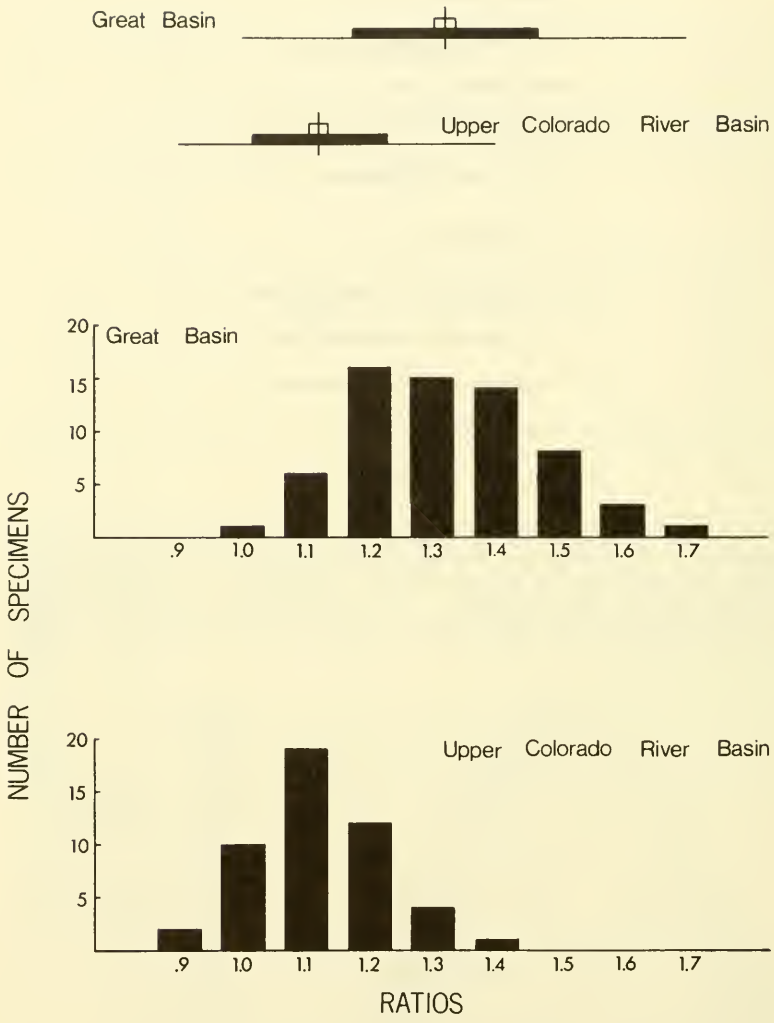

Figure 7. The ratios of the length of the average lateral frontonasal to the length of the median frononasal in the two major Utah populations of *Uta stansburiana*. Symbols as in Fig. 1.

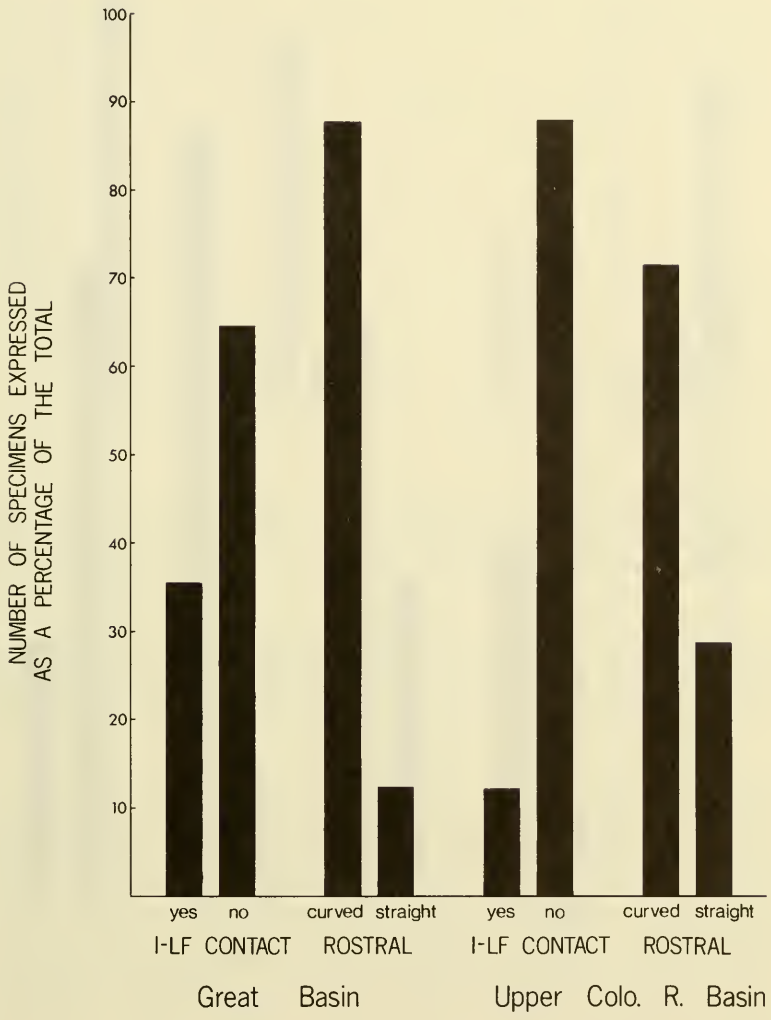

Figure 8. Internasal—lateral frontonasal contact, and shape of the upper edge of the rostral in the two major Utah populations of *Uta stansburiana*.

All measurements were made with a metric ruler or by using an ocular micrometer in a dissecting microscope. Where applicable, statistical tests of significance (as discussed by Mayr, Linsley, and Usinger, 1953) were applied to the data. They included: Chisquare test ($P = 0.05$ level of significance), comparison of means by calculating the standard error of the difference between the two means, and a

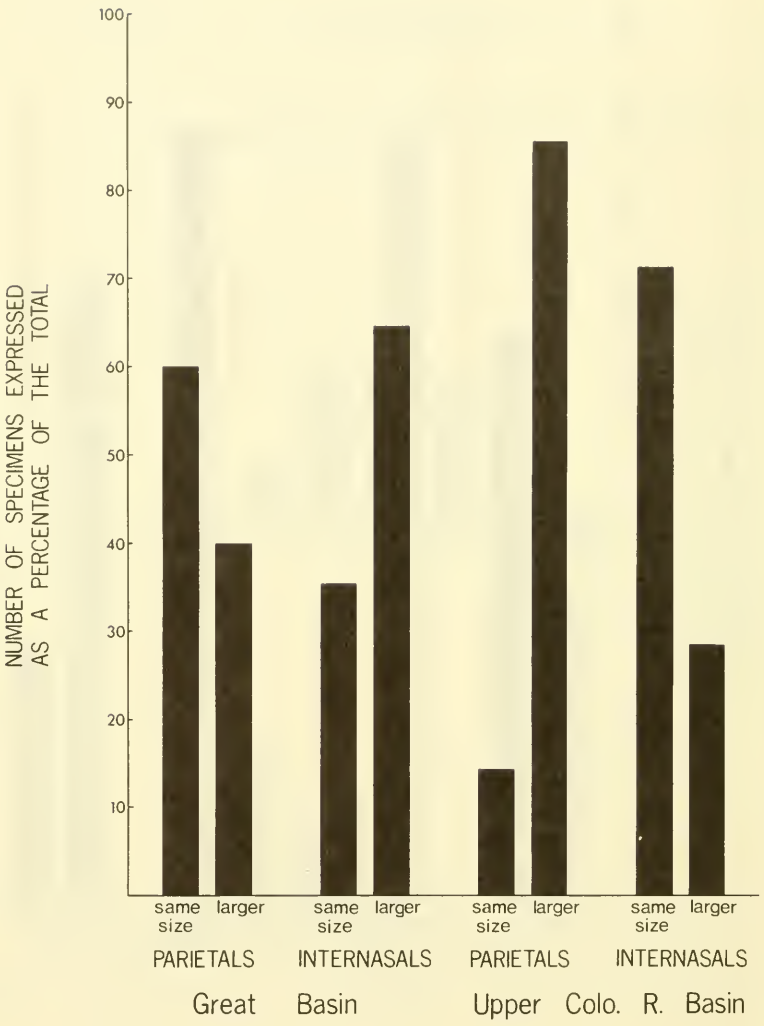

Figure 9. A camparison of parietal size with the frontoparietals and supratemporals, and anterior internasals with the posterior internasals in the two major Utah populations of *Uta stansburiana*.

determination of the percentage of overlap between populations by the calculation of the coefficient of difference.

Discussion

Analysis of variation indicates the presence of two subspecies of *Uta stansburiana* and possibly a third in Utah. The Great Basin and

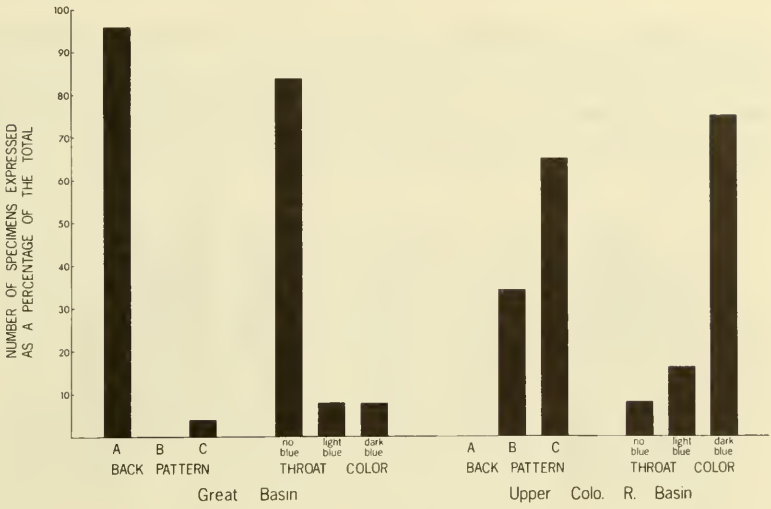

Figure 10. A comparison of the three possible conditions of back pattern and throat or gular coloration in the two major Utah populations of *Uta stansburiana*. Back patterns: (A) typical *Uta* pattern of stripes chevrons, or U-shaped marks; (B) spotted pattern, usually in rows; (C) uniform color without a pattern of light or dark markings.

Upper Colorado River Basin contain two distinct populations, and Washington Co., may contain a third or represent a zone of intergradation between these two and perhaps a population to the south.

Color Patterns

All of the Upper Colorado River Basin specimens examined were either without a back pattern or have regularly or irregularly scattered small dark brown spots; whereas 96% of the Great Basin specimens examined have some form of the typical *Uta* back pattern of stripes, chevrons, or U-shaped marks. This difference is adequate to satisfy the 75% rule of subspecific differentiation as stated by Mayr, Linsley, and Usinger (1953). Ballinger and McKinney (1967) found patternless individuals to be rare in the Texas population of *U. s. stejnegeri*. Tinkle (1969) states that *U. s. stansburiana* "is small, with little or no pattern, and with little sexual dimorphism." Obviously his statement is based on utas observed in the Upper Colorado Basin of western Colorado and eastern Utah (Fig. 11). However, such is not the case for utas from the Great Basin of western Utah and Nevada. With few exceptions utas from the Great Basin (*U. s. stansburiana*) are highly dimorphic in their color pattern (Figs. 12 & 13).

The difference observed in blue throat color (91.8% of the Upper Colorado River Basin population with blue throat, and 84% of the Great Basin population without), although not as nomenclaturally significant as the back pattern, is adequate to distinguish nearly all individuals. Figs. 11 and 12 show the typical dorsal and ventral mark-

ings of these two populations, and a New Mexico population from near the type locality of *U. s. stejnegeri*.

We suspect that there may be many types of selective pressure operating and that many environmental complexities may exist. The following are cited as examples that may be acting as selective pressures on one or both of these populations.

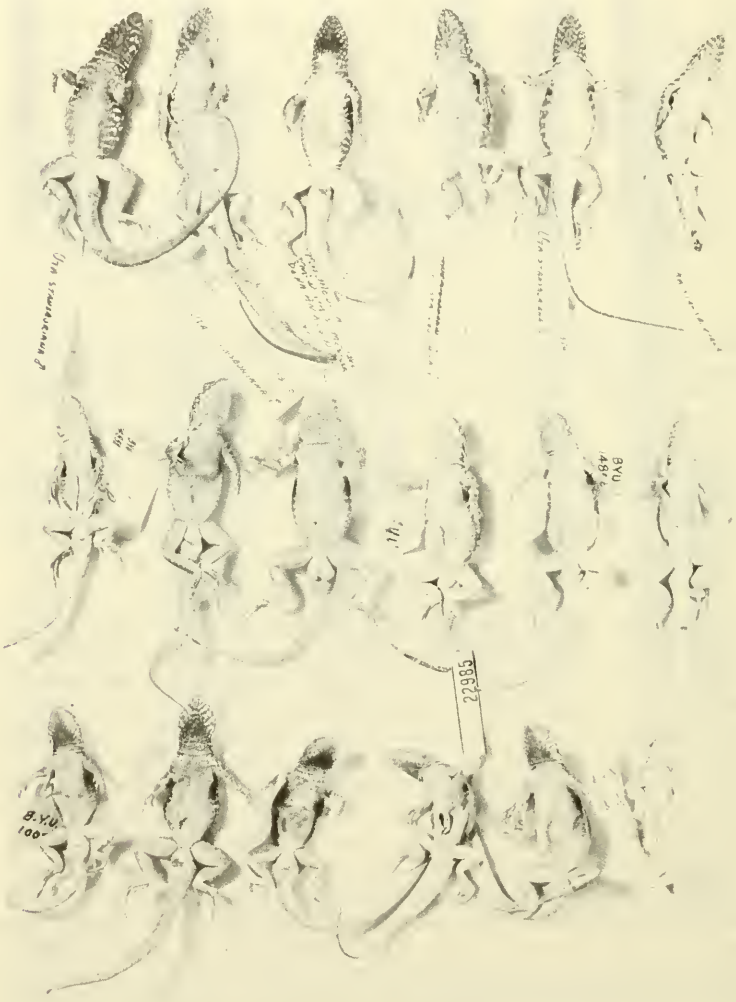

Figure 11. Dorsal views of three male (left side of figure) and three female (right side of figure) *Uta stansburiana* from three different populations: top row) Dona Ana County, New Mexico; middle row) Great Basin in Utah; and bottom row) Upper Colorado River Basin.

A lizard whose occurrence is not as general but nevertheless rivals *Uta stansburiana* in abundance at scattered locations throughout the Upper Colorado River Basin (as well as to the south) is *Urosaurus ornatus*. Although these species usually occupy distinctly different niches in the environment we have found them basking on the same rocks. Because of their similarities (in overall size, color, shape, courting, defense behavior, and the overlapping of habitat preference in

Figure 12. Ventral views of three male (left side of figure) and three female (right side of figure) *Uta stansburiana* from three different populations: top row) Dona Ana County, New Mexico; middle row) Great Basin in Utah; and bottom row) Upper Colorado River Basin.

the Upper Colorado River Basin) there may have been exerted selective pressure favoring the development of differences between them, especially differences that would aid in the selection of mates of the same species during the breeding season. Examination of live specimens of these two species readily reveals that *Urosaurus* has a distinctly marked back, whereas *Uta* does not; and also a reddish-brown throat with greenish-blue patches on the sides of the belly whereas *Uta* has a blue throat and reddish-orange to orange color on the sides of the belly. These colors may be easily seen, especially in Urosaurus, by observing the lizards during their bobbing display.

Different types of habitat are found in the Great Basin and the Upper Colorado River Basin. The habitat in the Great Basin consists of a more dense plant cover growing in soil containing rocks, sand, and covered with plant debris. In the Upper Colorado River Basin there are more open areas between the sparse vegetation and the rocks and soil are mainly derived from the reddish sandstone formations. It seems probable that an irregularly patterned and colored lizard would be less likely to be seen by predators in the Great Basin; and a uniformly patterned reddish-brown lizard would be less likely to be seen in the Upper Colorado River Basin.

Scale Patterns

The differences in the ratio of lateral frontonasal length to median frontonasal length, the number of dorsal scales, parietal size, and internazal size, although not adequate to satisfy the 75% rule, are sufficiently great to allow the separation of most Great Basin and Upper Colorado River Basin specimens. The distinction is even greater if these characters are used in combination with each other or with the back pattern and throat color characteristics.

The additional characters which show significant differences do not, by themselves, justify the separation of the Great Basin and Upper Colorado River Basin populations; but when included with more significant characters provide clues to evolutionary trends within these populations, and therefore support their separation.

The presences of larger anterior internasals and larger lateral frontonasals in Great Basin specimens probably accounts for their being more frequently in contact in this population. If this is the case, this characteristic (anterior internasal - lateral frontonasal contact) should probably not be included as a separate character, but considered instead as a result of the same gene modifications which produced the larger sized anterior internasals and lateral frontonasals.

In 1965, Tanner noted variation in six local populations of *Uta* in the uranium areas of the central Upper Colorado River Basin. Tanner's data suggested smaller dorsal scales than in this study with an average mean of 103.44 for 1,261 specimens. Part of this discrepancy can be explained from the fact that over 1,000 of these were from areas west of the Colorado and Green Rivers where dorsal counts average 105 to 106.

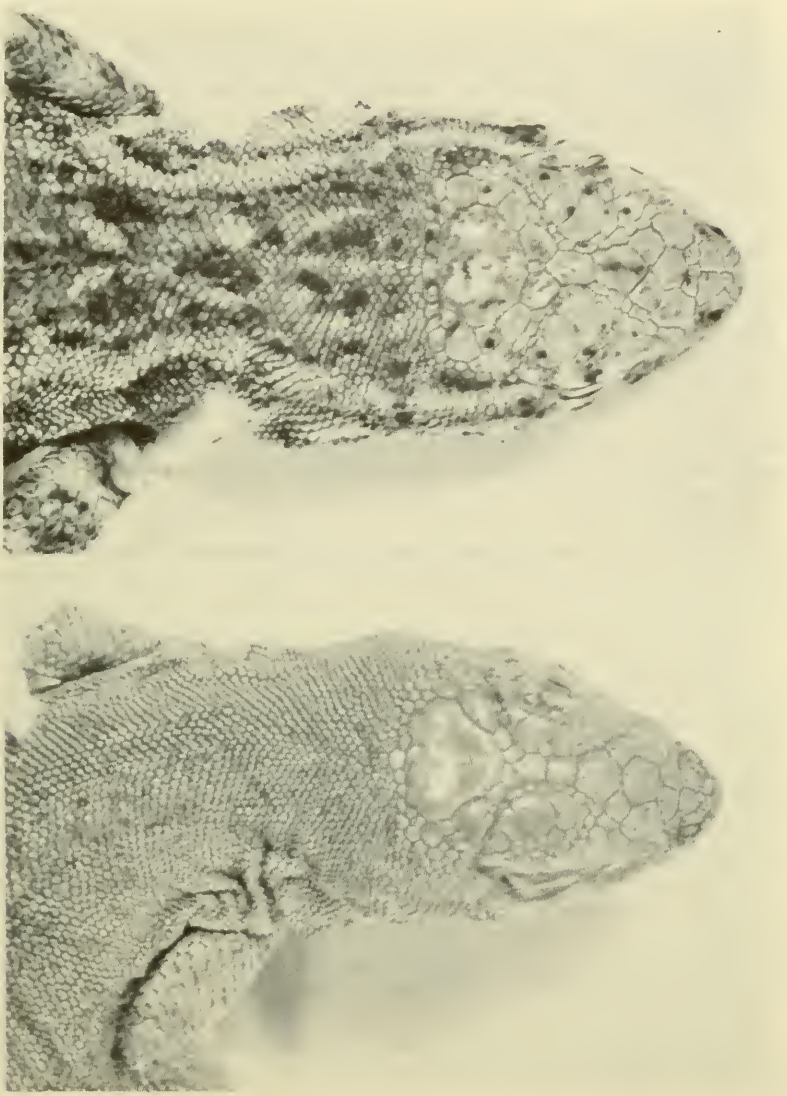

Figure 13. Dorsal view of the head of *Uta stansburiana* (top) BYU 9063, female and *Uta stansburiana uniformis* (bottom) BYU 22985 female.

A series of 270 specimens from Grand County east of Green River City and north of the Colorado River have lower counts, with a mean of 99. Specimens from western Colorado average 102 to 103. These variations may result from river barriers or deep canyons which impede or stop movement and thus increase isolation of segments of a widespread population.

The current separation of *U. s. stansburiana* from *U. s. stejnegeri* is based, in part, on the number of dorsal scales (94 or more in *stansburiana*, 93 or fewer in *stejnegeri*). The presence of a distinct population within the range of what has been called *U. s. stansburiana* with a significantly larger number of dorsal scales than specimens from near the type locality of *stansburiana* presents the problem of redefining the difference, in this character at least, between these two subspecies. Ruthven's (1913) *U. s. nevadensis* from northern Nevada was described as having dorsal scales one-fourth or one-fifth smaller than *U. s. stansburiana* (which should result in a larger number of scales, the lizards being about the same size). In 1915, Richardson found an average of 103.4 dorsal scales in a series of *Uta* collected primarily from northern Nevada. A comparison of their data with our data on the number of dorsal scales in specimens from western Utah indicates that there might be two distinctly different populations in the major basins of the Great Basin as Ruthven proposed. It definitely indicates the need for a more thorough study of all Great Basin utas.

The Great Basin and Upper Colorado River Basin populations were found in contact at two locations, in western Wayne and Garfield Counties. In both areas individuals with intermediate characters were found. In Washington and Kane Counties, Utah a broad area of contact between populations occurs in the Virgin River Valley.

The Sevier River (which drains into the Great Basin) extends into western Garfield Co., and closely approaches western Wayne Co., we have seen distinctly patterned *Uta* in Bryce Canyon National Park at an elevation of more than 7,600 feet. These *Uta*, plus the previously mentioned Upper Colorado River Basin specimens which show distinct back patterns, suggest that the Great Basin population extends to near the head of the Sevier River drainage and may extend into the western tributaries in this part of the Upper Colorado River Basin. Apparently as a result of the altitude and competition with the presumably better adapted *Sceloporus graciosus*, which is much more abundant in this area, few *Uta* are found. The reduced numbers of individuals would lead to fewer and infrequent contact, and thus minimal interbreeding between these populations.

A more extensive series of specimens from Washington Co. includes specimens intermediate between the Great Basin and Upper Colorado River Basin populations. These also appear to be intermediate between both populations and a population to the south. If this is the case, a zone of three-way intergradation occurs and thus probably an area of greater complexity than almost any area within the range of *Uta stansburiana*. Additional series of specimens from the south (Arizona), west (western Nevada and eastern California), and east from St. George would be necessary to determine accurately the relationships of these lizards to the other *Uta* populations. The relative abundance of specimens from western Kane County with the spotted back pattern may also indicate intergradation between the Great Basin and Upper Colorado River Basin populations.

Because the type locality of *Uta stansburiana stansburiana* is in the eastern Great Basin, and no other name has been based upon the Upper Colorado River Basin population, a new name for the latter must be proposed. In recognition of the almost completely patternless condition of the back, we propose:

Uta stansburiana uniformis subsp. nov.

Holotype.—Adult Male, BYU 10035, from Split Mountain, Uintah County, Utah, obtained by Wilmer W. Tanner, 21 May 1950.

Paratypes.—UTAH: Uintah Co., topotypes BYU 10036-7; Duchesne Co., Roosevelt, BYU 13030-2; Carbon Co., Price, 22985-7; Emery Co., Lower Temple Mountain Mesa, BYU 21231-2, 21235, 21240-1, 21245; Grand Co., Yellow Cat Mining District, BYU 20179; Wayne Co., Hanksville, BYU 8398, COLORADO: Moffat Co., UCM 5524-5, 5527, 5529; Delta Co., UCM 32655-7; Montezuma Co., UCM 4880-3, New Mexico—San Juan Co., 13 miles W of Farmington, BYU 32328-31.

Types are in the collection of the Brigham Young University Museum of Natural History (BYU) and the University of Colorado Museum (UCM).

Diagnosis.—This subspecies is most closely related to *U. s. stansburiana* from which it may be distinguished by the almost complete absence of a back pattern (or, if present, a pattern consisting of rows or irregularly scattered small [1-4 scales] dark brown spots); distinct blue color on the throat or gular region; a larger number of dorsal scales, average 101.6 as opposed to an average of 93.3 in *stansburiana;* parietals usually more than 1½ times the size of either the supratemporals or frontoparietals (85.7% in *uniformis*, 40.0% in *stansburiana*); and the anterior and posterior *internasals* usually of about the same size (71.4% in *uniformis*, 35.4% *in stansburiana*).

Description of the type: total length 111 mm; snout-vent length 43mm; 102 dorsal scales; 63 ventral scales; rostral width 2.4 times greater than height, upper edge concave on both sides; two postrostrals between right anterior internasal and rostral, one postrostral between anterior internasal and rostral; anterior and posterior internasals approximately same size; ratio of average lateral frontonasal length to median frontonasal length is 1.25, lateral frontonasals separted from anterior internasals by 0.2 mm; two normal-sized prefrontals separated by smaller median prefrontal; frontal divided transversely into two scales, anterior about 1½ times longer and wider than posterior; five frontoparietals; parietals conspicuously larger than frontoparietals and supratemporals; five supratemporals, the left posterior supratemporal divided longitudinally; interparietal with single scale set in concavity on posterior edge; eight occipitals contacting posterior edge of interparietal; four supraoculars on each side, separated from parietals by two rows of circumorbitals, and

from frontoparietals and frontals by one row of circumorbitals; supralabials to point below middle of eye 5-5; infralabials to point below middle of eye 7-6; femoral pores 14-14.

Back uniformly gray in alcohol, without pattern, except for irregularly scattered blue scales (common in males of this species), and occasional small dark brown spots not conforming in shape or size to shape or size of scales. Light spots on sides diminishing in size towards back; ventral surface with scattered patches of dark pigment blending into darker color of sides and back; black spots on sides behind forelegs large, 20 scales long by 15 wide. Throat or gular region heaily pigmented with dark blue. Tail uniformly colored without pattern except for small blue spots on anterior dorsal portion (Figs. 11, 12, and 13).

Range.—Upper Colorado River Basin (Colorado, Green, and San Juan River Drainages) upstream from Glen Canyon Dam, including SE Utah, W Colorado, NW New Mexico, and NE Arizona, and intergrading with subspecies to the west through SW Utah and NW Arizona.

Specimens Examined

Most of the specimens came from Brigham Young University (BYU) collection, and included the following numbers: *Great Basin*—492,616, 621, 623, 1018, 1690, 1691, 2078, 2785, 3314, 3315, 4185, 4193, 4194, 5323, 8197-8200, 8325, 8790, 8793-94, 8938-40, 9063-66, 9307-13, 9817-20, 10054-56, 10178, 10188-91, 10275, 10377, 11505-07, 11525-27, 11529-31, 12456, 12933, 13074-76, 14855-67, 14869-75, 15080-87, 16599, 16600, 21036, 21922, 21928-33, 23573, 32342-44; *Upper Colorado River Basin*—191, 589, 596, 624, 1002, 1706, 1827-30, 1885, 1901-03, 1918, 2155, 2249, 2743, 2983, 3400, 3432, 4178-82, 4191, 8398, 9044, 10035-37, 11265, 11266, 11852, 11873, 11874, 11901, 12442-44, 12448-53, 12455, 12492, 12695-98, 12967, 13029-33, 14189, 14664-65, 14924-25, 14930-32, 14934, 16796, 17752-58, 17892, 18960-61, 18995-96, 20172-82, 20198-12, 20303-09, 20977, 21230-45, 21410-12, 21545-52, 21567-68, 21597-08, 21863, 21936, 22102, 22103, 22985-87, 23566, 23567, 32322-25, 32327-37, 32349-51; *Washington County, Utah*—571, 673, 708, 1213, 2251-52, 3277, 3287-88, 3347-48, 3352-53, 3654, 4195, 8947, 8947, 9722, 9821-23, 9830-37, 12965, 16578-79, 32355-64.

Upper Colorado River Basin specimens examined from the University of Colorado are as follows: 2303, 2301, 4096, 4849, 4851, 4859, 4863, 4878-4883, 4890-91, 4893, 4899, 4901, 5524-25, 5527, 5529-30, 17491, 17479, 17503, 32627, 32630-31, 32633, 32635-37, 32641-43, 32650-52, 32654--57, 32659-60, 32664, 32668-69, 32671, 32674.

The Dona Ana County specimens were of two unnumbered series (19 specimens in one, and 27 in the other) from the University of Texas at El Paso. A series from the same area was received from Mr. Philip A. Medica.

We are grateful to the following for materials received on loan: Dr. T. Paul Maslin, University of Colorado; Dr. Robert G. Webb, University of Texas at El Paso; and Mr. Philip A. Medica, Mercury, Nevada. We are also grateful to Dr. B. F. Harrison and other members of the BYU staff, Dr. H. M. Smith and Dr. Denzel Fergeson for suggestions and reading of the manuscript. The photographs and plates were prepared by the senior author.

Table 1

Numerical results for 11 characters, based on a summarization of data to include: variation, mean and one standard deviation. *Uta* populations are as follows: (1) Great Basin, (2) Upper Colorado River Basin, (3) Southern New Mexico, (4) Washington County, Utah.

	Populations considered			
Characters	1 (N=103)	2 (N=208)	3 (N=46)	4 (N=30)
Dorsal Scales	82-113(93.3)5.05	91-116(101.2)5.49	77-93(85.0)3.39	79-97(88.8)4.27
Ventral Scales	54-66(59.9)2.43	54-68(61.1)2.73	53-70(61.4)3.26	54-66(59.7)3.0
Femoral Pores	23-32(28.1)1.83	24-36(29.1)1.91	26-34(30.3)1.83	25-32(28.7)1.85
Supra labials	7-10(8.6)0.77	7-11(8.6)0.74	7-9(8.0)0.33	8-10(8.4)0.62
Infra labials	10-15(12.7)0.97	11-15(12.6)0.84	10-13(12.0)0.47	10-15(12.5)0.97
Front parietals	2-8(3.2)1.21	2-6(3.3)1.17		
No. scales between Interparietal and Supraocular	4-7(5.8)0.53	4-6(4.9)0.85		
No. occipitals in contact with Interparietal	5-10(7.1)1.23	5-10(7.6)1.10		
Snout-vent length	40-51(45.4)3.05	39-48(43.4)2.59		
Rostral shape	.39-.59(.494).045	.40-.60(.50).045		
Frontonasal length	1.0-1.7(1.32).146	.9-1.4(1.12).105		

In this study we have made use of the many specimens gathered by the junior author while working in southeastern Utah under research Grant AT(11-1) 819, United States Atomic Energy Commission.

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LEPTOTYPHLOPS HUMILIS IN DEATH VALLEY, CALIFORNIA

Fenton R. Kay[1]

Leptotyphlops humilis has been recorded from six localities in Death Valley, California (Turner and Wauer, 1963). Herein are reported two new collection localities. In addition, environmental factors are discussed which may relate to distribution and physiology of the species.

In April, 1966, a single *Leptotyphlops humilis* was collected in the extreme southern end of the valley at Saratoga Springs, San Bernardino Co., California. The snake was found in leaf litter on coarse, moderately packed soil beneath a large salt cedar tree (*Tamarix aphylla*). In April, 1967, five *L. humilis* were taken in the extreme northern end of the valley near McClean Springs, Inyo Co., California. The specimens, along with several cast skins, were found in a 77 cm deep depression in dark, silty soil overlain by 15-21 cm of salt crust. The vegetation at the locality is largely salt grass (*Distichlis spicata*). Both localities are within Death Valley National Monument. All specimens are on deposit in the Biology Museum, University of Nevada, Las Vegas.

Klauber (1940) noted that specimens of *Leptotyphlops* from Death Valley could be referred to *L. humilis humilis* (Baird & Girard), even though they showed a slight increase in scale counts and color characteristic of *L. h. cahuilae* Klauber. Klauber (1940) pointed out that pigmentation and scale counts are diagnostic for *L. h. humilis* and *cahuilae*. Subsequent authors have followed Klauber's (1940) nomenclature.

The specimen from Saratoga Springs has the number of median dorsal scales (273), number of scale rows (14) and number of pigmented scale rows (7) characteristic of *L. h. humilis*, but the pigmentation is light brown, as seen in *L. h. cahuilae*, and the most ventro-lateral scale row on each side is only partially pigmented. The specimens from McClean Springs have a higher dorsal scale count than is characteristic of *L. h. humilis* (X= 281; range, 277-289) and are pigmented like the Saratoga Springs specimen. The other characteristics are those of *L. h. humilis* (no. scale rows, 14; no. pigmented rows, 7). I would, therefore, follow Klauber's (1940) nomenclature and refer all of the specimens to *L. h. humilis*, with the observation that they tend toward *L. h. cahuilae* in color and number of dorsal scales, especially in the northern end of the valley.

Little is known about the environmental factors which affect *L. humilis*. Klauber (1931, 1940) recorded soil types and ambient temperatures associated with surface-active *Leptotyphlops*, and Turner and Wauer (1963) recorded elevations and plant commun-

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Table 1—Summary of known and estimated chemical and physical characteristics of ground water and soil, and elevation, associated with collection localities of *Leptotyphlops humilis* in Death Valley, California.

N.D.=no data.

	% soil salts	pH soil	pH ground water	% TDS ground water	soil type	Elevation (Meters)
Bennetts Well	< 2.7 (1)	ca. 10.0 (1)	7.9 (1)	.03-.04 (1)	silt (4)	-75.8
Shortys Well	2.7 (1)	< 10.0 (1)	6.9 (1)	.07 (1)	silt (4)	-75.8
Gravel Well	2.7-3.8 (1)	ca. 10.0 (1)	6.8-7.0 (1)	.13 (1)	sandy gravel (4)	-60.6
Saratoga Springs	1.6-1.8 (2)	10.7-11.1 (2)	7.8-8.5 (3)	< .50 (3)	alluv. gravel	59.1
Furnace Creek	.25-.50 (1)	< 10.0 (1)	ca. 7.0 (1)	.20 (1)	silty gravel (4)	-54.1
Cow Creek	2.7-3.8 (1)	ca. 10.0 (1)	7.5-8.5 (1)	.15-.57 (1)	alluv. gravel (4)	-54.1
McClean Springs	2.4-3.8 (1)	> 10.0 (1)	7.6 (1)	1.73-2.80 (1)	silt	-27.6
Wildrose	< 2.0 (1)	N.D.	N.D.	N.D.	rocky alluv. (4)	1363.6

(1) Hunt, et al., 1966
(2) Bradley, 1970.
(3) Deacon, 1968
(4) C.G. Hansen, pers. comm.

ities at collection localities in Death Valley. Another species, *L. dulcis*, is known to aggregate in apparent response to soil moisture (McCoy, 1960) and to show definite soil type and temperature preferences (Clark, 1967).

Table 1 summarizes certain characteristics of soil and ground water, and gives elevations at the eight localities in Death Valley where *L. humilis* has been found. The data have been taken from several sources (Hunt, et al., 1966; Deacon, 1968; Bradley, 1970; C. G. Hansen, pers. comm.). All localities are associated with surface water or stream beds and are therefore thought to have moderate to high amounts of soil moisture. Ambient temperatures at the collection sites are not available.

Soil salinity at McClean Springs may be higher than indicated by the data at certain times; i.e., after rains. The salinity levels at McClean Springs and some of the other localities may indicate an efficient osmoregulatory mechanism or resistance to environmental salinity in *L. humilis*.

I thank Greg E. King for his assistance, James E. Deacon, Peter J. Mehringer, Jr. and James F. LaBounty for the specimens from McClean Springs, and James E. Deacon for the specimen from Saratoga Springs. Charles G. Hansen identified the soil types, and Michael J. O'Farrell and A. Dean Stock made helpful suggestions. Portions of this study were supported by U. S. National Park Service contract no. 14-10-0434-1989 to Dr. James E. Deacon.

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COMMENTS ON LESQUERELLA HITCHCOCKII

James L. Reveal[1]

In 1966 Barneby described a new subspecies of *Lesquerella hitchcockii* from bare white shale knolls southeast of Cannonville in Kane County, Utah. In 1967 I had an opportunity to recollect his ssp. *tumulosa* and compare it with my previous impressions of ssp. *confluens* of central Nevada and ssp. *rubicundula* of the upper Sevier River drainage of Garfield and Piute counties, Utah. In 1966 I had seen a few plants of ssp. *hitchcockii* on the Charleston Mountains, but during the summer of 1968 it was possible to investigate this taxon more throughly on both the Charleston and Sheep ranges of Clark County, Nevada. These various field observations are now summarized and the taxonomy of the species complex reviewed.

Lesquerella hitchcockii was described by Munz (1929) from a small collection obtained by Edmund C. Jaeger and C. Leo Hitchcock in 1927. In 1941, Rollins proposed *L. rubicundula* from central Utah, and noted its clear relationship with *L. hitchcockii*. Maguire and Holmgren (1951) summarized the species complex and proposed that Rollins' species be reduced to the subspecific rank. At the same time, they called attention to a third form from the Quinn Canyon Range of Nye County, Nevada, which they named ssp. *confluens*. This new subspecies was somewhat intermediate morphologically between the sspp. *hitchcockii* and *rubicundula*, but more so geographically, and their name was designed to show this position. When Barneby added ssp. *tumulosa* to the complex, he so further expanded the definition of the species, as represented by the type of *L. hitchcockii*, that the entire taxon took on a rather heterogeneous nature. This is rather clearly seen in the life-forms of the various isolated populations. The plants of ssp. *hitchcockii* are small with few, short, closely branched caudices with only a few flowering crowns. The caudices of ssp. *confluens* are numerous and long with the several branches often rhizomatous. Unlike the typical subspecies, ssp. *confluens* forms large mats which tumble at will over the loose gravelly boulders and talus slopes on the upper ridges of the Quinn Canyon Range. The life-form of ssp. *rubicundula* is somewhat similar to that of ssp. *confluens* except the branches of the caudices are greatly reduced to only a few in number, and the elongated, often rhizomatous branches do not form mats at all. The ssp. *tumulosa* differs from all of these taxa in that it is densely compacted into a small rounded cushion with several hundred crowded flowering crowns.

Other morphological features shared by these subspecies are less striking and the differences between the various populations becomes somewhat statistical (Maguire & Holmgren, 1951). However,

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differences can be seen in the leaf characteristics, size of the siliques, and the length of the styles, although in all cases the differences are slight. In general it may be stated that the flowers of *Lesquerella* are essentially similar throughout the range of the genus in the West and are of limited value as a diagnostic characteristic. To a much lesser degree, however, are the siliques which have considerable diagnostic importance, but seeming only in separating species groups; and, to some degree, in separating *Lesquerella* from the related genus, *Physaria* (Mulligan, 1968). Consequently, in this genus, it seems likely that one should concentrate on the numerous vegetative features of the plants in arriving at taxonomic entities rather than the flora characters.

With this in mind and considering the geographical isolation of each entity and the likelihood of no possible gene exchange (see Ehrlich & Raven, 1969), it seems that the proper taxonomic rank for each of the above subspecies should be at a higher level.

Key to the Species

1. Plants open and spreading, not at all compact or cushion-like.
   2. Rosettes 2-20 per plant; caudices composed of few slender, ±decumbent, branches; leaves 5-12 mm long.
      3. Leaves 2-4 mm wide, spathulate to broadly oblanceolate, tapering abruptly to a distinct petiole; styles 3-4.5 mm long; Charleston and Sheep ranges, Clark Co., Nevada. 1. *L. hitchcockii*
      3. Leaves 1-2 mm wide, linear to linear-oblanceolate, tapering gradually into a scarcely distinct petiole; styles 1.5-3.5 mm long; Piute and Garfield cos., Utah. 3. *L. rubicundula*
   2. Rosettes several hundred; caudices composed on numerous elongated, spreading, branches forming large mats; leaves 10-24 mm long, 1-3 mm wide, oblanceolate to elliptic, tapering to a short, but distinct, petiole; styles 4-6 mm long; Quinn Canyon Range, Nye Co., Nevada. 2. *L. confluens*
1. Plants densely caespitose and cushion-like with several hundred flowering rosettes; caudices short and compacted, buried in the mass of decomposed vegetation and covered with numerous persistent leaf-bases; leaves linear, 3-10 mm long, 0.7-1 mm wide, tapering gradually into a scarcely distinct petiole; styles 1-2 mm long; north-central Kane Co., Utah. 4. *L. tumulosa*

1. *Lesquerella hitchcockii* Munz, Bull. Torrey Bot. Club 56: 163, 1929. Type: High exposed ridges at 10500 ft elev, Charleston Mts, Clark Co., Nevada, 1 Sep 1927. *Jaeger & Hitchcock s.n.* Holotype, POM! Distribution: Charleston Mountains and the Sheep Range, Clark Co., Nevada, from 7500 to 11000 ft elev. Flowering from June to September.

As now outlined, *Lesquerella hitchcockii* is restricted to two high mountain ranges in southern Nevada, the Charleston (or Spring) Mountains and the adjacent Sheep Range. I have seen this species on both ranges, but on the Charleston, it is always at a higher elevation than it is on the Sheep Range. In spite of repeated efforts on the part of Janice C. Beatley, and to a lesser degree, efforts on my own part, this species has not been discovered on the high mountain ranges north of the Charlestons (Beatley, 1969). Thus, a distinct geographical gap exists between *L. hitchcockii* and the next species.

2. *Lesquerella confluens* (Maguire & Holmgren) Reveal, stat. & comb. nov., based on *L. hitchcockii* ssp. *confluens* Maguire & Holmgren, Madroño 11: 174. 1951. Type: Loose gravelly soil on a ridge N of Cherry Creek Pass, Quinn Canyon Range, at 7000 ft elev, Nye Co., Nevada, 20 Jun 1945, *Maguire & Holmgren 25534*. Lectotype, NY! Isotype, UTC! Distribution: Upper ridges of the Quinn Canyon Range, Nye Co., Nevada, from 7000 to 10000 ft elev. Flowering from June to August.

Lesquerella confluens is proposed as a new species based on its distinctive vegetative features and unique life-form. So far as known, it is restricted to the Quinn Canyon Range. When I saw this species in 1965, I felt at the time it was worthy of specific recognition. As Noel H. Holmgren and I were searching as many of the high mountain ranges as possible for *Primula nevadensis* (Holmgren, 1967), and we never discovered *L. confluens* anywhere else, I must conclude that it is likely restricted to this single range. How widely distributed the species is on the range is not known. Holmgren and I obtained our specimens a short distance to the northeast of the type location. However, when we were on the range in 1968 some distance south of Cherry Creek Pass, we failed to find the species although we did not climb above 8000 feet in elevation. It is possible that *L. confluens* may be found elsewhere. *Primula nevadensis* occurs both on the Quinn Canyon Range and the Snake Range, and Holmgren and I discovered *Tanacetum diversifolium* D. C. Eat. from the Quinns in 1968, a taxon previously known only from the Wasatch Mountains and the Deep Creek Mountains in northern Utah. However, also in spite of repeated searches, *Lewisia maguirei* Holmgren (1954) is known only from the Quinn Canyon Range.

3. *Lesquerella rubicundula* Rollins, Contr. Dudley Herb. 3: 178. 1941. *L. hitchcockii* ssp. *rubicundula* (*Rollins*) Maguire & Holmgren, Madroño 11: 175. 1951. Type: Red Canyon, Powell [now Dixie] National Forest, Garfield Co., Utah, 6 Jul 1912, *Eggleston 8198*. Holotype, US! Distribution: Red clay and gravelly places in Garfield and Piute cos., Utah, from 6700 to 7500 ft elev. Flowering from May to July.

Of all the taxa treated in this paper, this one is best known. It is commonly collected and represents one of the more frequently seen of the several Red Canyon endemics (Reveal, 1970). Also, it is perhaps the closest form to typical *Lesquerella hitchcockii* as re-

ported by Rollins (1941), Maguire and Holmgren (1951), and Barneby (1966). However, as noted by all of these authors, it differs in several vegetative features and essentially so in life-form, although in this regard the differences are less striking than those exhibited by *L. confluens* and *L. tumulosa*. In the several local populations that I have seen on and off since 1964, the degree of elongation of the caudices seems to depend to some extent on the pitch of the slope as noted by Barneby (1966). However, this does not always appear to be the case. On the flat ridges south of Red Canyon, I saw this species growing with *Cryptantha ochroleuca* Higgins (1968) and it had elongated caudices much in the same fashion as I saw on the plants on the slopes below the ridge. Unlike *L. hitchcockii*, the leaves of *L. rubicundula* are very narrow and lack a distinct petiole. The styles are shorter on the whole, although this feature is not paramount. The range of *L. rubicunduia* is restricted to a small area around the Bryce Canyon area and northward in the Sevier River drainage to the Marysvale area, but to the north it is rare. To my knowledge, the species has not been found west of the Tushar Mountains.

4. *Lesquerella tumulosa* (Barneby) Reveal, stat. & comb. nov., based on *L. hitchcockii* ssp. *tumulosa* Barneby, Leafl. West. Bot. 10: 313. 1966. Type: Bare white shale knolls 6.5 mi SE of Cannonville, Kane Co., Utah, *Barneby 14424*. Holotype, NY! Isotypes, BRY, CAS, GH, UC, US, UTC! Distribution: White shale knolls near Kodachrome Flat, southeast of Cannonville in Kane Co., Utah, at ca 5700 ft elev. Flowering from April to June.

This species is the most depauperate of the various taxa treated in this paper, and it is the only member of the group that occurs in a decidedly desert environment. As all of the remaining taxa are montane plants, found at elevations above 6700 feet, *Lesquerella tumulosa* is the really odd member of the species complex. Barneby (1966), pointed out that this species is clearly related to *L. rubicundula*, but the two are so totally different in the field, that without careful study, this relationship could go undetected. The narrow leaves and the similarly shape silique allies the two species, but in the genus as a whole, one would likely associate *L. tumulosa* more with the compacted cushion species such as *L. nanum* S. Wats., *L. condensata* A. Nels., and *L. subumbellata* Rollins, than with the mat forming *L. confluens* or even *L. hitchcockii*. In the field *L. tumulosa* is restricted to only a few white shale knolls on a flat west of Kodachrome Flat. I did not find the species on any other similar slopes (which were rare themselves), and so the species is likely rather restricted in its distribution.

In summary past authors have tended to lump together four distinct and dissimilar geographically isolated forms of *Lesquerella* under a single specific name, *L. hitchcockii*. Recent studies in the field have shown that these four subspecies could better be recognized at the specific level as they differ in ecology, distribution, and several vegetative features. Two of the taxa, *L. hitchcockii* and

L rubicundula seem to be the basic elements in the evolution of the group, with *L. confluens* more closely related to *L. hitchcockii* and *L. tumulosa* closer to *L. rubicundula* than the two extremes are to each other.

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A PRELIMINARY REPORT ON THE ALGAL SPECIES PRESENTLY FOUND IN UTAH LAKE

William J. Harding[1]

Introduction

Utah Lake is a shallow, desert lake which has undergone a number of changes in its biology and hydrology through water control and other misuse during the past 100 years. It is interesting to note that although Utah Lake is one of the largest freshwater lakes in the western states, few published reports have appeared which deal with the algal flora. Tanner and his associates established the first research station on the Lake in 1926, which operated for many years. Tanner (1930, 1931) published a list of algal species found in the lake as part of a general biological survey. Within this list is found the only diatom genera recorded to date. Snow (1931), made a comprehensive study of the littoral algae, representing the most recent and accurate information available.

These earlier studies were concerned with the benthic and littoral algae and not the planktonic forms, evidenced by the species reported and the methods of collection. As a result, many of the plants listed herein have not been previously reported. This preliminary study is the first in a series to update and contribute to the known algal flora of Utah Lake.

For the following species a few descriptive notes, interesting observations and ecological data where deemed warranted are given and with some exceptions, each is illustrated. Material upon which this study is based is deposited in the private collection of the author.

Gratitude is expressed to Brigham Young University Research Division, The Central Utah Conservancy District, Geneva Works of United States Steel, Utah County Commissioners, and the Utah State Division of Health, who financially supported this project.

List Of Algal Species

Cyanophyta

Anabaena spiroides, var. *crassa* Lemmermann Pl. 1, Fig. 3.

Trichomes solitary, spirally twisted, and planktonic. The cells are spherical; heterocysts subspherical. Abundant throughout the lake, being very numerous during the late summer; appearing in blooms with *A. flosaquae*, *C. hirondinella*, and *M. aeruginosa*.

Microcystis aeroginosa Kuetz.

An ovate, spherical colony of numerous spherical cells which are much crowded within a gelatinous matrix. Common in Utah Lake,

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becoming especially abundant during late summer. Found most often around the Provo Harbor and Powell's slough areas.

Aphanizomenon flos-aquae (L.) Ralfs Pl. 1, Fig. 2, 3.

Trichomes parallel, tapering at both ends; united in bundles or flakes to form marcoscopic colonies. Heterocysts are oblong or cyndrical and scattered in the midregion of the trichome. This plant was a frequent component of water blooms. It occurred alone or in accompaniment with *Microcystis aeruginosa* and *Anabaena spiroides.* The occurrence of this species is so consistently related to hard water lakes usually with a high nitrogen and carbonate content that it may be used as an index organism.

Chlorophyta

Pandorina morum (Muell.) Bory Pl. 1, Fig. 4.

Colony ovate or obovoid, composed of 8-16-(32) globose or pyriform cells compactly arranged and enclosed by a common gelatinous envelope. Common among the dense growths of plankton in shallow water during the summer months.

Eudorina elegans Ehrenberg Pl. 1, Fig. 6.

Colony spherical or ovate with 16-32 cells evenly disposed within a gelatinous envelope, or arranged in transverse series. The cells are usually lying near the periphery of the envelope. Two long flagella are present. Common in the euplankton during the summer months.

Ulothrix zonata (Weber & Mohr) Kuetz. Pl. 2, Fig. 4.

Filament attached, usually long and stout, variable in diameter in the same plant mass. Cells short, or elongate-cylindric; cell walls thick. Chloroplast a complete circular band in the midregion of the cell. Common in late spring when the water is still cool.

Cladophora glomerata (L.) Kuetz. Pl. 2, Fig. 8.

C. glomerata became very abundant during the summer months in the shallow waters of Lincoln Beach, Bird Island, and around the Provo Boat Harbor, these being places offering suitable substrate for solid attachment.

Chlorococcum infusionum (Schrank) Meneghini Pl. 1, Fig. 5.

Cells spherical, solitary or in small clumps, variable in size within the same plant mass; cells 15-45 μ in diameter. Ordinarily found in submerged substrates or attached to the legs of zooplankton.

Dictyosphaerium Ehrenbergianum Naegeli Pl. 2, Fig. 12.

Colony ovoid, composed of ellipsoidal cells with one or two parietal or cup-like chloroplasts, cells attached in groups of 2 or 4 at the ends of fine, branched strands. Found in the plankton around the Provo River and Harbor during the summer.

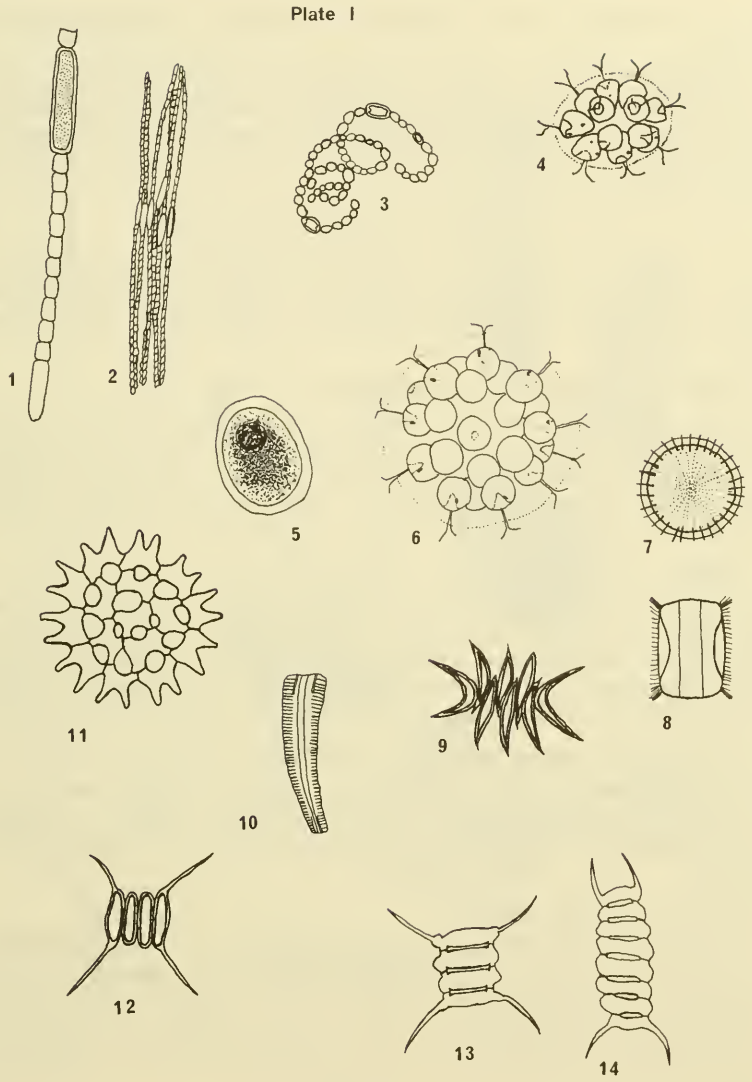

Plate 1

Figs. 1-2, *Aphanizomenon flos-aquae* (L.) Ralfs.; 3, *Anabaena spiroides* var. *crassa* Lemmermann; 4, *Pandorina morum* (Muell.) Bory; 5, *Chlorococcum infusionum* (Schrank) Meneghini; 6, *Eudorina elegans* Ehrenberg; 7-8, *Stephanodiscus niagrae* Ehr.: 7, valve view; 8, girdle view; 9, *Scenedesmus dimorphus* (Turp.) Kuetzing; 10, *Rhinosphenia curvata* (Kutz.) Grun.; 11, *Pediastrum duplex* var. *clathratum* (A. Braum) *Lagerheim;* 12, *Scenedesmus quadricauda* (Turp.) Kuetzing; 13-14, *Scenedesmus perforatus* Lemmermann.

Pediastrum duplex var. *clathratum* (A. Braum) Lagerheim Pl. 1, Fig. 11.

Colony with larger perforations that in the typical form; walls with deep emarginations; apices of lobes of peripheral cells truncate; cells 12-20 μ in diameter. This alga was very common during the latter part of the year (from June to December) and was generally distributed throughout the lake.

Scenedesmus dimorphus (Turp.) Kuetz. Pl. 1, Fig. 9.

A colonial alga composed of 4 to 8 fusiform cells arranged in a single or alternating series; the inner cells with straight, sharp apices. Common in still water around the Provo River and Harbor from July to September.

Scenedesmus perforatus Lemmermann Pl. 1, Fig. 13, 14.

Cells subrectangular with convex end walls and concave lateral walls, thus forming biconvex intercellular spaces. The end cells bear a single long curved spine at each pole arising from the corner. The outer lateral walls of the end cells straight or umbenate. Found around the Provo River and Harbor area from July to September.

Scenedesmus perforatus Lemmermann Pl. 1, Fig. 13, 14.

Cells subrectangular with convex end walls and concave lateral walls, thus forming biconvex intercellular spaces. The end cells bear a single long curved spine at each pole arising from the corner. The outer lateral walls of the end cells straight or umbenate. Found around the Provo River and Harbor area from July to September.

Scenedesmus quadricauda (Turp.) Kuetz. Pl. 1, Fig. 12

Colony consisting of 2-4-8 oblong cylindric cells usually in 1 series. The outer cells have a long curved spine at each pole; inner cells without spines. Common and widely distributed throughout the summer.

Selenastrum Gracile Reinsch

Colonies of 8-64 sickle-shaped cells in irregular arrangement, but with the convex surfaces opposed; apices of the cells sharply pointed; chloroplast a parietal plate among the convex wall, without a pyrenoid. Cells 3-5 μ in diameter, 19-28 μ between apieces. Found in the tychoplankton around the Provo River and Harbor area during late summer.

Botryococcus Braunii Kuetz. Pl. 2, Fig. 7.

Cells ellipsoid, radiately arranged at the periphery of irreguarly shaped usually dark-colored masses of mucilage. Chloroplast a think, or dense, parietal net with one pyrenoid covering only a portion of the wall. Cells 3-6 μ in diameter, 6-12 μ long. Common and often abundant during the winter.

Closteriopsis longissima var. *tropica* West and West Pl. 2, Fig. 1.

Cells long and needle-like, tapering but bluntly tipped at both

Plate II

Plate 2

Figs. 1, *Closteriopsis longissimi* var. *tropica* West & West; 2, *Tribonema minus* (Wille) Hazen; 3, *Tribonema bombycinum* (C, A. Ag) Derbes & Solier; 4, *Ulotrhix zonata* (Weber & Mohr) Kuetzing; 5-6, *Hydrurus foetidus* (Vill.) Trev.; 7, *Botryococcus Braunii* Kuetzing; 8, *Cladophora glomerata* (L.) Kuetzing; 9, *Dinobryon sertularia* Ehrenberg; 10, *Asterionella formosa* Hass.; 11, *Tabellaria floccosa* (Roth) Kutz.; 12, *Dictyosphaerium Ehrenbergianum* Naegeli; 13, *Ceratium hirundinella* (O. F. Muell.).

ends; 6-7.5 μ in diameter, 225-370 μ long. Chloroplast a lobed plate extending almost the entire length of the cells and containing a row of pyrenoids. Found in euplankton during the summer months.

Pyrrhophyta

Ceratium hirundinella (O. F. Muell.) Pl. 2, Fig. 13.

C. hirundinella was one of the most common plankters throughout the lake most of the year round. It was especially abundant during the summer in Mud Lake and around the Provo River and Harbor areas.

Chrysophyta

Tribonema bombycinum (C. A. Ag.) Derbes and Solier Pl. 2, Fig. 3.

Cells with thin walls; cylindrical or slightly constricted at the cross walls. Chromotophores 4-8 small, parietal, pale yellow-green discs, sometimes in contact giving the appearance of 1 or 2 large, irregular shaped plates. Filaments usually much entangled; however, short filaments of a few cells were only found in the limnoplankton.

Tribonema minus (Wille) Hazen Pl. 2, Fig. 2.

Filaments slender, cells slightly inflated to subcylindrical, 5-6 μ wide, 23-27 μ long; chromotophores 2-4 large parietal discs, symmetrically arranged about the wall. Also found in the limnoplankton.

Dinobryon sertularia Ehrenberg Pl. 2, Fig. 9.

Free-swimming, aborescent colonies of fusiform-campanulate loricas, slightly diverging. Loricas have a blunt-pointed posterior, smooth lateral margins, convex, narrowed above the mid-region and then slightly flaring to a wide mouth. Found around the mouth of the Provo River in February.

Hydrusus foetidus (Vill.) Trev. Pl. 2, Fig. 5-6.

A gelatinous thallus profusely branched, penicillate, and brown in color. Ovoid cells, each containing a single golden-brown chromatophore that generally lies on the side of the cell toward the thallus apex. Always found attached to rocks in early spring when the water was still cold.

Stephanodiscus niagrae Ehr. Pl. 1, Fig. 7, 8.

Frustules usually discoid, sometimes cylindrical; valves circular in outline and radially punctate ;with short, rather stout spines around the perifery. May have several small discoid chromatopheres or one or two large irregularly shaped ones. Common in the euplankton during late fall and winter.

Rhicosphenia curvata (Kutz.) Grun. Pl. 1, Fig. 10.

Frustules wedge-shaped, oblanceolate, in valve view. Attached at narrower end to branching system of gelatinous stalks affixed to

submerged phanerograms. There is a single laminate chromatophore next to one side of the girdle. Found attached to other algae throughout most of the year.

Asteroinella formosa Hass. Pl. 2, Fig. 10.

Frustules linear in valve view, joined to each other at edges to form flat stellate colonies with all cells lying in approximately the same plane. Two chromatophere to a cell lying axially to each other. Common in the plankton during most of the year.

Tabellaria floccosa (Roth) Kutz. Pl. 2, Fig. 11.

Tabular cells united in free-floating zig-zag chains; frustules with numerous intercalary bands between girles. Values elongate, with an evident lateral inflation in the median portion, and slightly inflated at the poles. Common both attached and in the plankton throughout most of the year.

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HERPETOLOGICAL DISTRIBUTION AND LIFE HISTORY NOTES FOR HAWAII AND WESTERN NORTH AMERICA

Distribution of *Dendrobates auratus* Girard in Hawaii.—In 1932, Mr. David T. Fullway introdnced two hundred and six *Dendrobates auratus* Girard into upper Manoa valley on the island of Oahu. The frogs according to Dunn (Oliver and Shaw, Zoologica 1953. 39:79) originated on the island of Taboga or Tabogilla in the gulf of Panama. While in Hawaii from September 1964 until June 1966, I made some observations concerning the migration of the frogs across the Koolau Mountain range. *Dendrobates* was found to be present as far north as Kahuku, however, only a few specimens were seen. These frogs were found generally only at an altitude where the humidity is high and the temeprature is cool. In captivity, I have found *Dendrobates* to do poorly at temperatures much above 70 F.

Rediscovery of *Lygosoma n. noctua* (Lesson) in Hawaii — Oliver and Shaw (1953, *Zoologica*, Vol 39:91) stated that *Lygosoma n. noctua* (Lesson) had not been recorded from the Hawaiian Islands since 1920. In the latter part of May 1966, I found a gravid female (BYU 30843) in the leaf litter under a large Banyan tree in Laie, Oahu. *Lygosoma metallicum* (O'Shuaghnessy) were also taken in large numbers in the same habitat. Although these species superficially resemble each other, *noctua* can be distinguished from *metallicum* by the divided frontoparietal and a prominent light occipital spot on the posterior edge of the interparietal usually continuing posteriorly as a narrow light mid-dorsal stripe. According to Oliver and Shaw, *Lygosoma noctua* is the only ovoviviparous lizard known to occur in Hawaii. Upon dissecting the gravid female I found two developing embroyos, which is the normal number for this species. *Lygosoma metallicum* usually lays 3 or 4 eggs. The *noctua* specimen is now in the herpetological collection at Brigham Young University.

Hemidactylus frenatus in Hawaii — On three separate occasions *Hemidactylus frenatus* Dumeril and Bibron has been found on Oahu. I collected the first specimens in March 1966 on the dormitory walls at the Church College of Hawaii in Laie. In August of 1967, a series was collected at Laie, and also one at Sacred Falls. In July of 1969, several specimens were sent to me from Honolulu, indicating that the gecko is rapidly becoming widespread on the island. It is not known how *frenatus* reached the islands, however, a good guess may be that they arrived at Laie in the luggage of visiting polynesians and orientals.

Prior to the first specimens of *frenatus* being collected in 1966, *Gehyra mutilata* (Wiegman) along with *Lepidodactylus lugubris* Dumeril and Bibron were common on the dormitory walls. With the introduction of *frenatus*, *G. mutilata* seemed to decline in numbers, however, *L. lugabris* could still be found in large numbers, possibly because people placed them indoors as a mosquito control. On the buildings adjacent to the dormitories *G. mutilata* and *Hemidactylus garnoti* were the dominant species. *L. lugubris* being noticeably spotty in its distribution. By August of 1967, *H. frenatus* had become the dominant species of all the geckos taken from the buildings adjacent to the dormitories. They had also increased considerably within the confines of the buildings. *G. mutilata* and *H. garnoti* could be found primarily on buildings that were somewhat isolated and not frequented by people, and under rocks and other debris in the general area.

H. frenatus is one of the largest of the geckos on Oahu, equalled only by *H. garnoti*, however, the latter is more secretive whereas the former is a "House Gecko" from the Orient. These facts have probably played a major role in the rapid spread of *frenatus* on Oahu.

A note on Reproduction in *Sceloporus j jarrovvi* Cope. — Smith (Hndbk. of Lizards, 1946) states that *Sceloporus j. jarrovvi* Cope belonging to the Tor-

quatus group should be ovoviviparous but that no record of this has been reported in the literature.

On June 4, 1969, I obtained a gravid female (S-V 70 mm, BYU 32464) from Millers Peak in the Huachuca Mountains, Cochise County, Arizona. The lizard gave live birth to four young on July 8th. The young measured 20.4 - 20.5 mm and weighed 1.13 grams collectively.

Despite attempts to keep the hatchlings alive by feeding wingless fruit flies, all the young died by the end of July. They are now in the BYU collection (BYU 32460-63).

Another female (S-V 75 mm, BYU 15810), collected on June 28, 1950, by W. W. Tanner and Robison 25 miles from Colonia Juarez on the road to Tres Rios, Chihuahua, Mexico; contained seven fully developed embryos (BYU 32578-84) with only a small amount of yolk remaining. The S-V measurements were averaged at 22.57 mm (21 mm - 24 mm).

Upon examination of the embryos, it was noted that the males had their hemipeneses everted thereby fascilitating sexual recognition. The sex ratio was found to be four females and three males.

From the present data, it may be stated that *jarrovii* gives birth during the last week in June and first two weeks in July.

I wish to thank Dr. W. W. Tanner for his helpful suggestions in reviewing this paper.— J. Robert McMorris, Graduate student, Department of Zoology and Entomology, Brigham Young University, Provo, Utah.

THE RATTLESNAKE CROTALUS ATROX IN SOUTHERN NEVADA

Linsdale (1941) reported four specimens of *Crotalus atrox* from the extreme southern tip of Nevada at the Colorado River opposite Fort Mohave, Clark County. Stebbins (1966), on the basis of Linsdale's records, shows *C. atrox* extending into the southern tip of Nevada. On 9 April 1970, a male *C. atrox* was collected 1 mile south of Searchlight, Clark County, on State Highway 95, at an elevation of approximately 3,400 ft. Searchlight is approximately 50 airline miles northwest of Fort Mohave. This specimen is the first *C. atrox* reported in Nevada since 1936 and represents the northernmost occurrence for this species in the Southwest.

Normally a range extension of 50 miles would not be significant. However no previous specimens of *C. atrox* are known from west of the Colorado River in Nevada. For Mohave is located on the eastern side of the river. We plan additional field work to determine whether a population of *C. atrox* exists in the Searchlight area.

The specimen (R5118), on deposit in the Biology Museum at University of Nevada, Las Vegas, was collected at 11:00 A.M. at air temperature approximately 28° C. It weighed 753 g and had snout-vent length of 163 mm.— Andersen, B. B. and F. H. Emmerson, Department of Biological Sciences, University of Nevada, Las Vegas 89109.

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REVISION OF THE HEDYSARUM BOREALE COMPLEX

Terry E. Northstrom[1] and Stanley L. Welsh[2]

Introduction

The *Hedysarum boreale* complex includes all North American members of the genus *Hedysarum* which possess free wing auricles, subequal calyx teeth, wingless loment articles, and obscure leaflet veins.

Since *H. boreale* was first described in 1818 by Thomas Nuttall, numerous variants of this taxon have been described by various authors leaving a multitude of anomalous synonyms in the literature, and the number of species described seem to greatly exceed the number of populations occurring in nature. This has made identification of members of this group of taxa, using current floristic works and monographs, quite difficult.

This revision is an attempt to ascertain and depict the pattern of morphological variation and the geographical distribution of the natural populations of the *Hedysarum boreale* complex, and then to assign a valid name to each specific or infraspecific entity.

All critical herbarium specimens examined have been cited. The herbaria from which material was made available are indicated below, and are followed by their standard abbreviations as given by Lanjouw and Stafleu (1964).

University of Alaska Herbarium, ALA; University of Arizona Herbarium, ARIZ; Brigham Young University Herbarium, BRY; University of Colorado Herbarium, COLO; University of Montana Herbarium, MONT; Montana State University Herbarium, MONTU; North Dakota State University Herbarium, NDA; Oregon State University Herbarium, OSC; Bebb Herbarium of the University of Oklahoma, OKL; Herbarium of the Philadelphia Academy of Sciences, PH; South Dakota State University Herbarium, SDU; United States Forest Service Herbarium, USFS; University of Utah Herbarium, UT; Utah State University Herbarium, UTC.

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Review of the Literature

Hedysarum boreale was first described by Thomas Nuttall in his *Genera of North American Plants* (1818). The type specimens upon which he based his description have been lost, and this, along with Nuttall's own misunderstanding of the plant, has led to numerous misconceptions concerning the identity of *H. boreale*. In his original description, which is given below (1818, p. 110). Nuttall indicated that he was not entirely sure that his plant was not *H. alpinum* of Michaux.

> Caulescent, subdecumbent, leaves pinnate (7 or 8 pairs), leaflets oblong-abovate, partly villous; racemes long pedunculate, axillary, stipules sheathing, subulate; articulations of the loment nearly round, and rugose, *H. alpinum?* Mich. Fl. Am. 2. p. 74. Hab. in arid and denudated soils around Fort Mandan, on the banks of the Missouri. Flowering in June and July. Flowers of a fine red and numerous; common petiole very short; calix subulate, wings of the corolla short (*sic.*).

The description is a poor one but there are several points within it which rule out the possibility of *H. alpinum* as being the entity he was describing. Most important is the type locality, which is cited by Nuttall as "in arid and denudated soils around Fort Mandan." *H. alpinum* has not been found in that area; in fact, O. A. Stevens (1950) in his *Handbook of North Dakota Plants* does not report *H. alpinum* or any other species of *Hedysarum* except *H. boreale* for the state, leaving little doubt that the plant Nuttall described was indeed *H. boreale*. Additionally, Nuttall describes the stipules of his plant as subulate; the articles of the loment as rugose, and the calyx as subulate. These terms cannot be applied to *H. alpinum*. In *H. alpinum* the stipules are acute, the calyx teeth are triangular and the loment articles are reticulated but never rugose.

Although several workers have dealt with portions of the *H. boreale* complex, no comprehensive study has been made. Fedtschenko (1902) published a world revision of the genus *Hedysarum*, but his treatment of American plants left much to be desired. He failed to recognize the two natural groups into which the American species of *Hedysarum* fall, and subsequently he placed *H. boreale* in synonymy with *H. alpinum*. As can be seen from his specimen citations, the extent of Fedtschenko's examination of American plants can at best be described as meager.

Per Axel Rydberg (1922), in his *Flora of the Rocky Mountains and Adjacent Plains*, attempted a comprehensive treatment of *Hedysarum* but he, too, failed to recognize the two natural subdivisions of the genus. His hastily made judgments regarding species delimitation were evidently based on an inadequate number of specimens, since the characters which are truly diagnostic within the complex were not utilized in his keys or descriptions. Instead he emphasized the structure of the loments, especially the width of the internodes, the pattern of the reticulations, and the quantity of pubescence. In

addition, Rydberg seems to have been unaware of the edaphic and climatic influences on the dispersal and evolution of species, and evidently felt that it was necessary to preserve all of the taxa that had previously been described from the area.

The only significant attempt at a long-needed revision of the North American species of *Hedysarum* was that of Rollins (1940). He recognized the two natural groups into which the American species fall and correctly placed into synonymy many formerly disputable and confusing names. The paper, except for a few hastily made combinations, was precisely done, its most serious defects being its lack of experimental or cytological data, its lack of illustrations, and its exclusion of the Yukon Territory and Alaska.

Delimitation of Taxa

The taxon described herein as *H. boreale* ssp. *mackenzii* has numerous synonyms, the most commonly accepted being either *H. boreale* var. *mackenzii* or *H. mackenzii*. Although an argument can be presented in favor of the application of the above ranks, the choice ultimately depends upon the definitions of the taxonomic categories involved. Although precise rank is not inherent in an entity and is determined primarily by custom, the treatment here is based upon a synthesis of the current trends in the usage of the taxonomic categories by contemporary taxonomists.

The species as it is used here may be defined as a natural population of genetically closely related individuals which are separated from other species by gaps of genetic discontinuity in morphological and physiological characters and which are maintained by the absence of gene exchange. Although a definition such as this cannot always be applied with accuracy, it is quite applicable to the North American species of *Hedysarum*. *H. alpinum*, *H. boreale*, *H. occidentale*, and *H. sulphurescens* are all separated from each other by nearly complete gaps in the assemblage of characters, and apparently little intergradation occurs between them.

One immediately realizes that because of the nature of the evolutionary process, the species may become subdivided into numerous segments, each occupying a more or less distinct area and nearly entirely confluent in morphology. A group of entitles of this type is here recognized as a subspecies. They are morphologically distinct, they occupy a distinct area, and they would undoubtedly be considered as separate species by many authors, were it not for a certain degree of intergradation which they exhibit. In the following treatment, they differ not only in geographical distribution and morphology, but also in the type of habitat which they occupy. Furthermore, their areal extent is rather large in proportion to the total distributional range of the species. Although the subspecies is not popular in some circles, probably because Linneaus did not use it, it appears to be gaining acceptance due primarily to the lack of standard usage of the varietal rank.

The subspecies may be used as a hierarchical category that contains one or more small populations, herein called varieties, which are to some extent morphologically and often geographically distinctive but assume a much more localized distribution, in contrast to the commonly wide range of the subspecies. It is important to recognize that in *H. boreale* there are different levels of infraspecific variation, and thus there must be different kinds of subspecific entities. The classical rank below the level of species, the variety, is not suitable to depict all the types of infraspecific variation that occurs within *H. boreale*, and thus the hierarchical usage of both the subspecies and the variety is appropriate. At the same time, one must also recognize the limits of such a nomenclatural scheme, as too complete an analysis would result in a loss of purpose and usefulness. For this reason and because of the remarkable number of ecotypes found within *H. boreale*, no further infraspecific categories below the variety will be utilized here.

Numerous formae have been described in the past by various authors, and many times that number, each possessing at least equal stature, could be recognized. But as indicated by the tremendously wide range of variation which *H. boreale* exhibits, a recognition of all the minor forms of variation which exist in a species with as broad a distribution as this one would merely result in cumbersome keys and descriptions. To illustrate this point one needs only to examine a thorough collection of Utah specimens. Here one finds pale, pink-flowered plants in central Utah, purple-flowered plants in northeastern Utah, a large flowered phase from the foothills of northern Utah, and an extremely small flowered phase from Bryce Canyon. In addition there are populations with a tendency toward abovate leaflets, lanceolate leaflets, and compact inflorescences, as well as populations with numerous other characteristics with even less stability. In essence, the main fault with some of the previous taxonomic treatments of the *H. boreale* complex has been the failure of their authors to recognize the importance and the extent of infraspecific variation that is apparently due to ecological adaptations.

Morphological Characters

Hedysarum boreale is a highly variable perennial chamaephyte, which exhibits great variation in flower size, degree of pubescence, shape and size of the leaflets, and structure of the loments. The abundance of synonyms herein enumerated is accounted for by the fact that much of the variation is haphazard and without taxonomic significance.

roots

The root is a stout, branched, ligneous taproot, which may reach several feet in length and which is subject to little modification, except for considerable variation in length and diameter, and appears to be of no taxonomic value at this time. The roots of ssp. *mackenzii* have been reported to be poisonous, although to our knowledge this

has not been verified. Sir John Richardson, during his early expedition to the arctic (1823), evidently mistook the roots of it for those of the edible *H. alpinum* and reported that several of his men became ill after eating it.

CAUDEX

The caudex consists of from several to many stem bases which give rise to the herbaceous stems during the second and following years of growth. The nodes of the caudex branches are surrounded by thin, papery, connate, sheathing stipules. The perennating buds are found at about the level of the soil and usually give rise to a small amount of vegetative growth late in the fall before dormancy sets in.

STEMS

The stems are numerous, solid, terete, and longitudinally grooved, with the degree of branching and the length of the internodes being highly variable characters. They vary from decumbent to erect, and apparently never root along the nodes. The ssp. *mackenzii* is generally sparsely branched or even unbranched, in contrast to the often profusely branched ssp. *boreale;* but considerable variation from this pattern occurs, and thus the character cannot be regarded as diagnostic.

STIPULES

The stipules are subulate, pubescent, and usually connate, although the upper are sometimes free. The texture varies from membranaceous and white-translucent with brown streaks, to dark brown. The ssp. *mackenzii* consistently has thin, papery, white-translucent stipules while those of ssp. *boreale* may vary considerably but are usually brown.

LEAVES

The leaf of *H. boreale* is a petiolate odd-pinnate structure which bears from five to fifteen petiolulate leaflets with obscure veins, and a well defined midrib which extends to the apex. The obscure venation is diagnostic, but for some reason its significance was not recognized by the early workers.

The leaflets exhibit great variation in size, shape, and vesture; this variation is without taxonomic significance in nearly all cases. The lower leaflets are usually ovate to elliptic, although linear or obovate forms are not uncommon; whereas, the upper leaflets are usually considerably narrower and often lanceolate in shape. They vary in vesture from glabrous to canescent above and from pubescent to canescent below.

VESTURE

The herbage of all the entities within the complex are beset with some and usually many hairs. Apparently, no qualitative differences in pubescence exist. The hairs are generally from 0.5 to 1 mm in length and are straight, appressed, smooth, and silvery. They tend

to be more abundant on the upper leaves, on the inflorescence, and on the lower surfaces of the leaflets. The ssp. *mackenzii* consistently has leaflets which are green and glabrous above, and grayish green and pubescent below, whereas those of ssp. *boreale* exhibit considerably more variation but are usually pubescent on both leaflet surfaces, giving a satiny-strigose appearance; this condition reaches its extreme form in var. *cinerascens*.

INFLORESCENCE

The inflorescence is an axillary raceme which varies in the length of the peduncle and in the number of flowers. The flowers may be arranged in long, loose, interrupted racemes, as commonly occurs in ssp. *boreale*, or in subcapitate clusters as in ssp. *mackenzii*. Each flower is subtended by a single bract which is similar to the stipules in shape and texture and tends to vary in proportion with them.

CALYX

The calyx consists of sepals connate at the base and with apices produced into five equal, subulate, pubescent teeth. The tube is campanulate, bracteolate, and is beset with usually many straight, appressed, and satiny hairs. The length of the teeth and their length in proportion to the tube have, in the past, been used to delimit taxa within this complex, but they tend to vary considerably, and thus cannot be relied upon in classification.

BRACTEOLES

The flowers of all members of the *H. boreale* complex are bracteolate. The bracteoles occur in symmetrical pairs at the base of the calyx, and appear to be of no systematic importance. The origin and significance of these appendages is obscure, but they are probably homologous with the bracts, which they tend to resemble in form.

ANDROECIUM

The stamens are diadelphous, with the filaments of nine connate into a subcylindric sheath which envelops the ovary and the remaining one free to the base. They evidently lack diagnostic significance.

GYNOECIUM

The gynoecium consists of a single elliptical and laterally flattened ovary, which contains from two to many amphitropous ovules borne on a single parietal placenta. The style is slender, curved, and glabrous, and is topped by a minute stigma.

COROLLA

The corolla of *H. boreale* is papilionaceous and consists of an adaxial banner, two free wings, and a keel opposite the banner,

which is formed from two petals coalescent by their adjacent margins, and which encloses the androecium and gynoecium. The wing petals are symmetrical and each has a blunt basal lobe (auricle) which remains free over the ovary. Except for much variation in length and width, the banner and keel are subject to little modification. Occasionally, the angle of the keel will vary somewhat, but it is of no systematic value.

The petals vary in color from nearly pure white to pink, magenta, or purple, and are often conspicuously veined. The lowermost, or oldest, flowers of the inflorescence are often considerably darker than the upper ones and tend to be somewhat larger. The ssp. *mackenzii* tends to have larger and more showy flowers than does the ssp. *boreale*.

FRUITS

The fruit of *H. boreale* is a flat loment and is constricted into several oval, indehiscent, and one-seeded articles which break transversely. The articles have transversely elongated reticulations which give a corrugated appearance, and wingless margins, although occasionally the margins are thickened. In the ssp. *mackenzii*, anthocyanin pigments are often present within the margins and reticulations of the articles, giving them a dark green or black coloration. Many previous treatments of *H. boreale* have used the structure of the loment reticulations to delimit taxa, but this character is subject to much variation both in thickness and in pattern and has no systematic value.

H. boreale var. *gremiale* has peculiar setae or spine-like structures which arise from the reticulations of the articles and are covered with hairs. These spines occasionally appear on the articles of var. *cinerascens* also, although they are never as prominent as they are in some specimens of var. *gremiale*, and may vary from minute bumps to definite tubercles.

The morphological characters that develop in a plant depend upon the environment as well as the genotype. It is evident that some genes are more sensitive to environmental fluctuations than others, and thus may have variable expressions, depending upon the particular environment in which they develop. It is quite likely that many, if not all, members of the *H. boreale* complex have the potential of developing spiny fruits, but that certain environmental conditions throughout much of the range are unsuitable for their production. The existence of intermediates with respect to the spines of var. *gremiale* strongly suggest the presence of a gene for spines which has variable expressivity, or which is modified by another gene which has variable expressivity.

The evolutionary trend in the fruit of *H. boreale* appears to be toward a reduction in the number of articles. Although ssp. *mackenzii* has a greater number of loment articles than has ssp. *boreale*, this seems quite appropriate, since it also has a much more reduced inflorescence and far fewer flowers; perhaps the greater number of loment articles compensates for the reduction in flower number.

Phylogeny

Hedysarum boreale ssp. *mackenzii* occurs from eastern Siberia to Newfoundland and south to British Columbia and Quebec, while ssp. *boreale* is found from British Columbia and Alberta, southward through Montana, Idaho, and North Dakota to Arizona and New Mexico (Figure 1). Where the two populations converge, plants with intermediate combinations of characters are found. These intermediates have been found from the Wallowa Mountains in Oregon, and east through southern British Columbia to central Alberta. From a close examination, it appears that a distribution such as this is best explained as a result of the extensive glaciation which is known to have occurred during the Pleistocene.

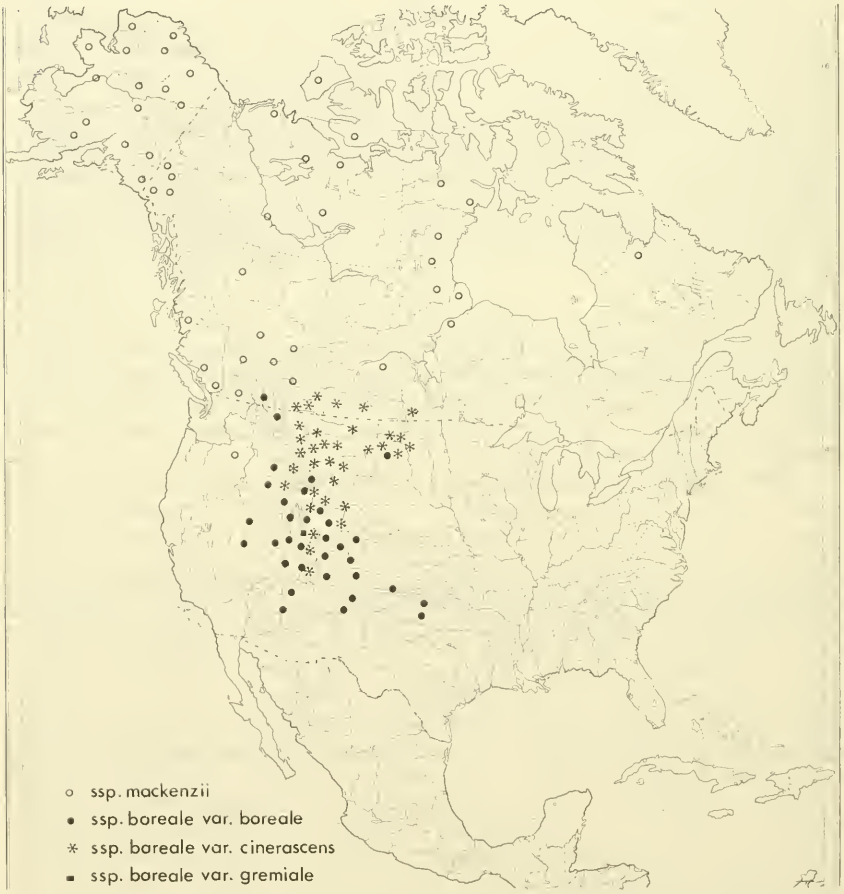

Fig. 1. Distribution of infraspecific taxa in the *Hedysarum boreale* complex.

It has been widely postulated that during the Pleistocene, because of a lack of sufficient precipitation for ice sheets to form, there were certain areas which remained unglaciated. It is thought that these unglaciated areas occupied a large part of what is now Alaska and the Yukon, portions of Quebec and Newfoundland, and numerous other smaller and more isolated areas (Hulten, 1937; Raup, 1941).

H. boreale had probably occupied most of its present range prior to the last major glaciation, but this old area became split into northern and southern segments which were separated by vast ice sheets during the Pleistocene. At the termination of the last glaciation, the species began to migrate back into its original area and eventually completely reoccupied its original range.

The segregation of the previous population into two isolated segments would tend to restrict the supply of genes available to each of these segments, and would tend to direct them into certain paths of adaptation. It is apparent that the ecological conditions found in the northern and southern areas would be vastly different from each other, and far fewer biotypes would be available for selection, especially in the north, than there were in the original area; thus, different ecotypes would be created which would later, after glaciation, give rise to major geographical races, but without the production of reproductive barriers. The initial divergence would thus be caused by the response of the ancestral population to different selection pressures, which resulted from ecological differentiation in the northern and southern portions of the original area.

It is logical to assume that the southern refugia would cover a much larger area, and the plants within it would be subjected to a wider variety of ecological conditions than would those in the north; thus, there would be more opportunity for gene flow and more phenotypic variation would be observed in the southern refugia.

It appears that this is what has occurred within the *H. boreale* complex. *H. boreale* ssp. *boreale* occupies a wide variety of habitats, and many trends of development can be observed throughout its wide range of distribution. In contrast, ssp. *mackenzii* is a pioneer and is restricted to plant communities which are in early stages of succession, especially gravel bars and areas which are flooded annually. In addition, ssp. *mackenzii* is a much more stable entity, and few trends of development are observed within it.

An attempt to explain a distribution such as this by a post glacial migration of a single species into the area, fails to account for the intermediate populations that are found in convergent areas. The only other plausible explanation would be to assume the existence of two distinct populations during preglacial times, but upon close examination of the two entities as they occur today, it is evident that the differences between them are primarily quantitive, and no truly qualitative differences exist.

The three varieties of ssp. *boreale* are differentiated either by the quantity of pubescence or by the presence of spines or hooks on the loment articles. That these characters are derived conditions in this taxon appears to be clear. Were the original population of *H. boreale*

densely pubescent, it would seem likely that densely pubescent forms would commonly occur in modern representatives of the species. But, ssp. *mackenzii* is seldom pubescent on both leaflet surfaces; furthermore, plants with dense pubescence are restricted to only a small portion of the area occupied by ssp. *boreale*.

It is also quite evident that var. *gremiale* and var. *cinerascens* are closely related. They are both usually pubescent on the upper and lower leaflet surfaces, and var. *cinerascens* commonly has definite tubercles on the loment articles. Specimens of var. *cinerascens* possessing these tubercles have been collected from Wyoming and Montana, and as far north as Alberta.

In summary, if one considers that (a) *H. boreale* ssp. *boreale* and *H. boreale* ssp. *mackenzii* are the result of the division of a pre-Pleistocene species of *Hedysarum*, and (b) that the dense pubescence of var. *cinerascens* is a derived character, and (c) that var. *gremiale* is most closely related to var. *cinerascens*, then a phylogenetic scheme can be proposed (Figure 2).

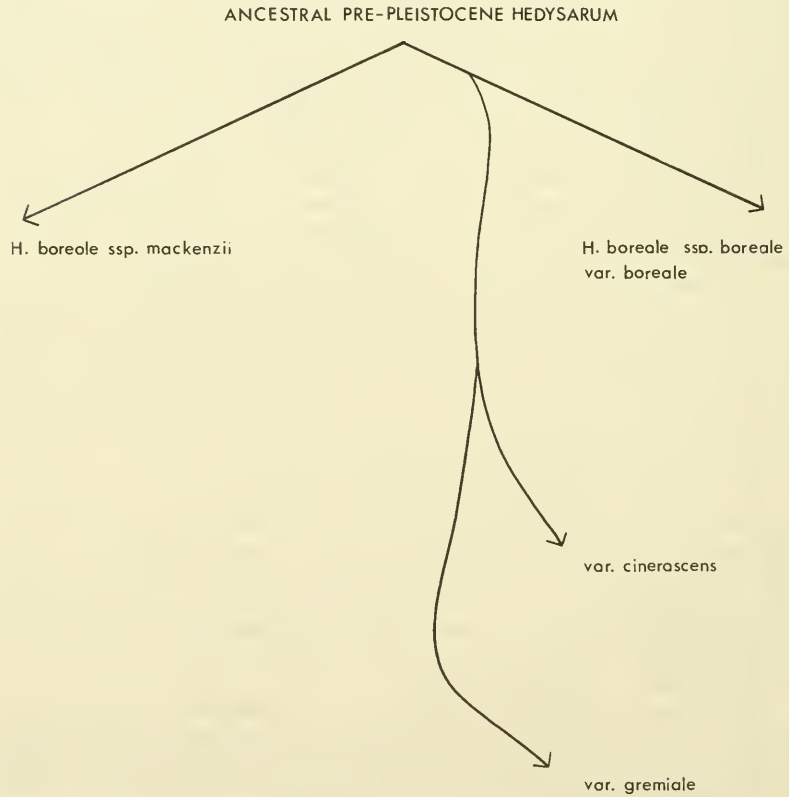

Fig. 2. Phylogenetic scheme of the *Hedysarum boreale* complex.

Methods

When working with a species with as broad a range of distribution as *H. boreale*, the examination of an adequate number of specimens becomes especially critical. During the course of this study approximately 400 specimens were examined. The objectives of these examinations were threefold: (1) to determine the scope and frequency of variation which occurs within the complex; (2) to ascertain the geographical range, and some knowledge of the ecological requirements of the populations within the complex; and (3) to write accurate descriptions of the natural populations as they occur in nature.

All measurements of specimens were made with a standard centimeter rule graduated in millimeters. Extremely small structures were measured with the aid of a low-power binocular microscope equipped with an ocular micrometer. The flowers were measured from the base of the calyx tube to the apex of the banner or wing, whichever was longer. Since dried floral parts are subject to considerable shrinkage, all flowers were soaked in a detergent solution prior to measuring. The loments were measured from the point of attachment to the calyx to the apex of the terminal article.

To compare the two taxa referred to here as *H. boreale* ssp. *boreale* and *H. boreale* ssp. *mackenzii*, a tabulation on a 0, 1, 2, basis was prepared for eight morphological characters (Table 1). A

Table 1. Arbitrary values assigned to eight morphological characteristics in the two subspecies of *Hedysarum boreale*.

	0	1	2
Flower Color	Purple	Intermediate	Pink to magenta
Inflorescence	Compact 0-6 cm.	7-12	Elongate Greater than 12 cm.
Leaflets	Green and glabrous above, grayish-pubescent below.	Intermediate	Grayish and pubescent on both surfaces.
Stipules	White translucent, brown streaked.	Intermediate	Brown
Length of Flowers	Greater than 20 mm.	17-19 mm.	Less than 16 mm.
Loment nodes	Narrow	Intermediate	Broad
Number of Loment Articles	6-8	5	2-4
Flower No.	5-15	16-20	21-45

polygonal graph was then prepared (Figure 3) depicting the averages of each character for each of the two populations. It is readily observed that the width of the loment nodes, a character often utilized in previous keys and descriptions, is of little or no taxonomic value.

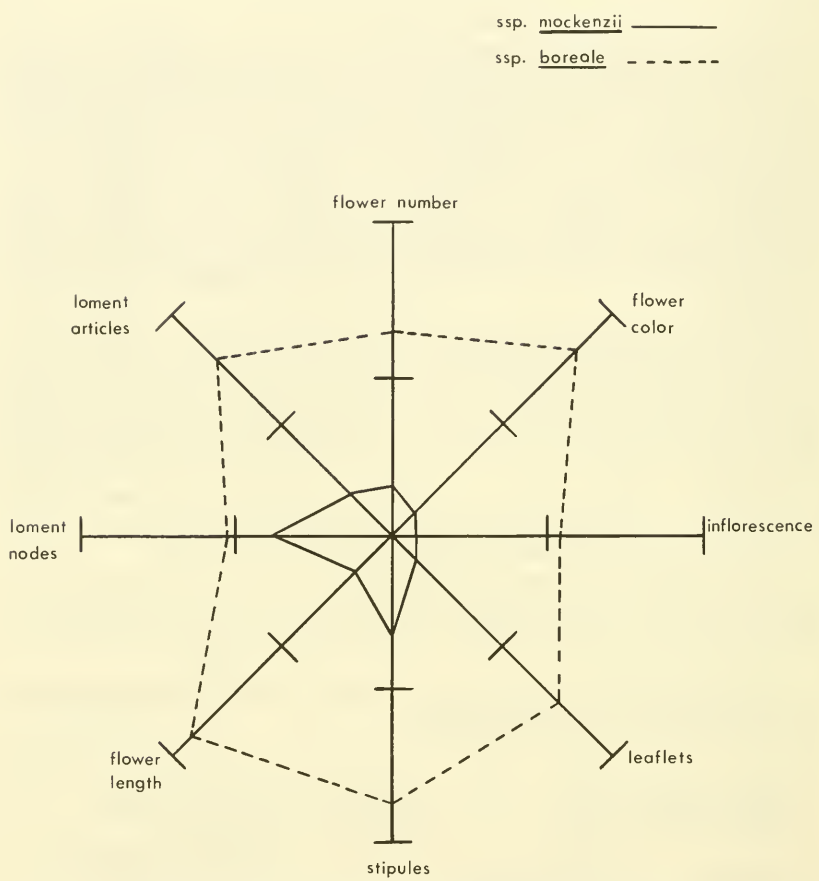

Fig. 3. Polygonal graph depicting averages for each of eight characteristics for ssp. *mackenzii* and ssp. *boreale* (based on values assigned in Table 1).

The total number of points for all characters, except those concerning the fruit, was then prepared for each specimen. The total possible range was from 0-12. The scores were then plotted in the form of a histogram which showed a distinct bimodal distribution, although some overlap between the two populations is readily apparent (Figure 4).

It is observed from the histogram that two distinct populations exist, but there is some overlap between them. Either the two races underwent complete divergence which was followed later by hybridization, or divergence was incomplete and localized swarms of intermediate individuals have been present since initial divergence began. But nearly all of the specimens with intermediate scores were found from the Wallowa Mountains of Oregon, and east to southern British Columbia and Alberta, which corresponds to the area of con-

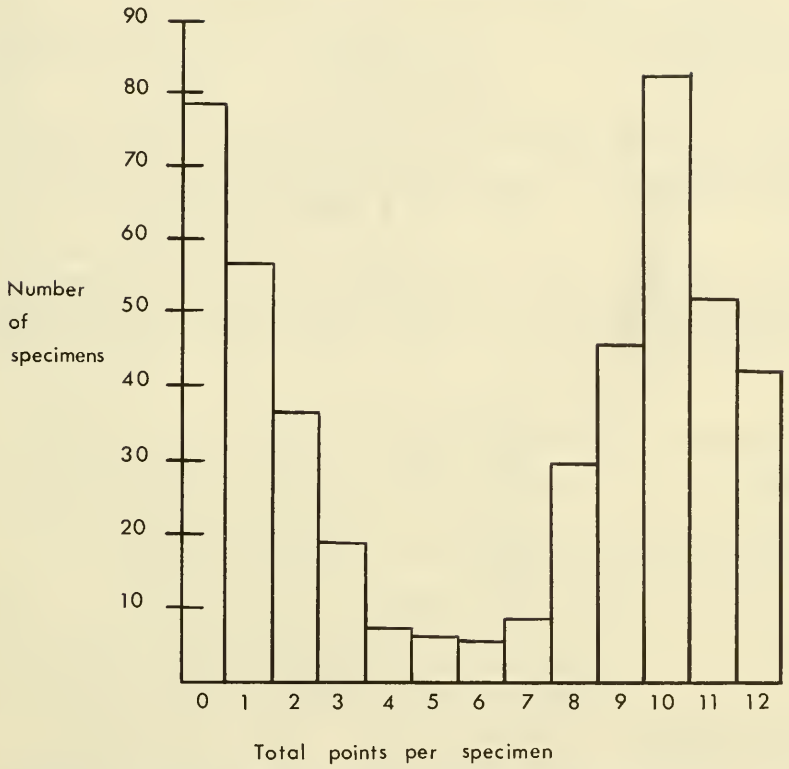

Fig. 4. Histogram based on the total points for all characteristics; 0-3 represents ssp. *mackenzii;* 8-12 represents ssp. *boreale;* 4-7 represents intermediates.

vergence of the two populations. Thus it appears that some gene flow occurs between the two entities in convergent areas (Figure 5).

Cytology

Somatic chromosome numbers were determined for all taxa occurring within the *H. boreale* complex. The somatic chromosome number of 16 was found in all taxa.

Taxonomy

Hedysarum boreale Nuttall, Gen. N. Am. Pl. 2:110. 1818.

Common Name: Sweetvetch.

Terrestrial, herbaceous perennials; roots stout, ligneous, 4-12 mm in diameter; stems 2 to many, decumbent to erect, longitudinally grooved, not rooting, 2.5-7 dm long, 1.5-5 mm in diameter, usually branched above, solid, terete, sparsely pubescent to canescent; stipules tan to brown, or white-translucent with brown streaks, with a sub-

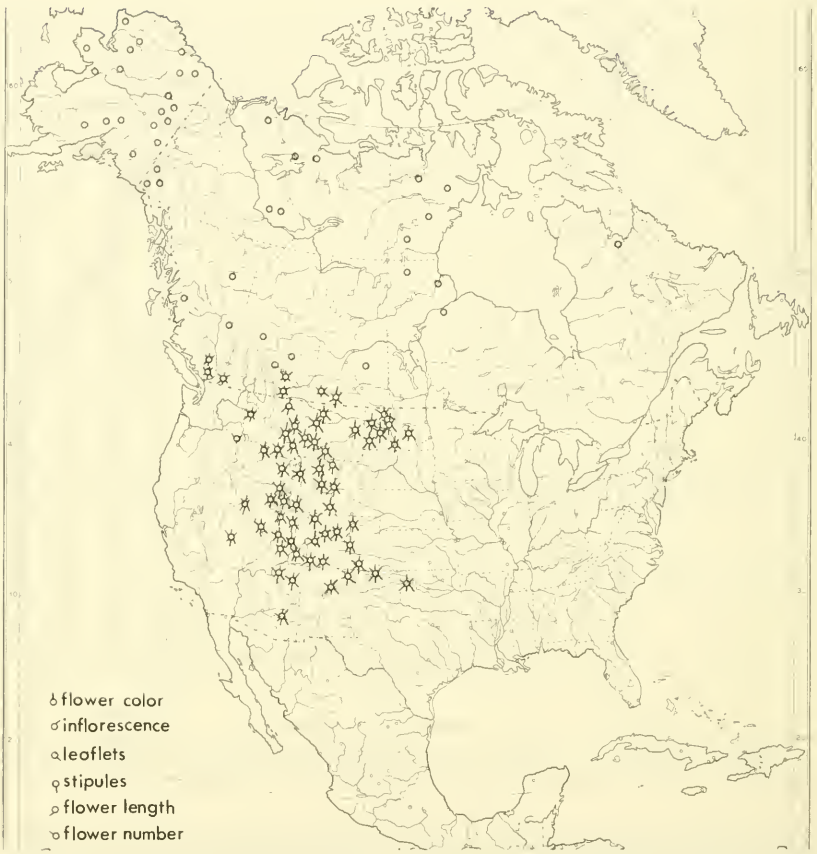

Fig. 5. Distribution of variability in *Hedysarum boreale* complex (based on values assigned in Table 1).

ulate tip, usually united, upper sometimes free, 2-10 mm long; leaves odd-pinnate, 3-12 cm long; leaflets 5-15, ovate, elliptic, linear, or obovate, canescent to glabrous above, canescent to pubescent below, entire, veins usually hidden, 10-35 mm long, 3-19 mm wide, apices rounded to obtuse; inflorescence racemose, 2-15 cm long, interrupted to compact; bracts subulate, brown, pubescent, 2-5 mm long; bractioles pubescent, linear, 1-3 mm long; flowers 5-45, erect to spreading, pink to purple, 10-26 mm long; calyx tube campanulate, 4-8 mm long, bractiolate, pubescent, calyx teeth 0.5-1.5 mm wide, 2-5 mm long, subulate, greenish, erect; standard obovate to cuneate or spatulate, apex emarginate, base cuneate, 8-16 mm long, 4-10 mm wide; wings 6-16 mm long, 2-5 mm wide; wing auricles blunt round, free, 1-2 mm long; stamens 10, diadelphous; style slender,

curved; loments pendulous to spreading; articles 2-8, pubescent or setaceous, stipitate, not wing-margined, prominently transversely reticulated.

Key to the Subspecies

1. Flowers mostly 10-19 mm in length, pink to purple; racemes 8-23 cm long; articles mostly 2-5. ssp. *boreale*
1. Flowers mostly 15-26 mm in length, usually purple; racemes compact, usually 2-10 cm long; articles mostly 3-8. ssp. *mackenzii*

Hedysarum boreale Nutt. ssp. *boreale*

Stems 2.5-7 cm long, usually branched above; stipules usually pale brown, occasionally brown streaked; flowers 13-45, 10-19 mm long, pink to magenta or purple; racemes elongated, 8-23 cm long; leaflets usually pubescent on both surfaces, occasionally glabrous above; articles 2-5, seldom black-pigmented.

Key to varieties of ssp. *boreale*

1. Articles of the loment covered with spines; leaves pubescent on both surfaces or glabrous above. var. *gremiale*
1. Articles of the loment lacking spines; leaves pubescent to canescent on both surfaces or occasionally glabrous above.
   2. Leaves glabrous to sparsely pubescent on upper surface. var. *boreale*
   2. Leaves markedly pubescent on both surfaces, whole plant grayish hairy or canescent. var. *cinerascens*

Hedysarum boreale Nutt. ssp. *boreale* var. *boreale* (Fig. 6, A-D)

H. carnosulum Greene Pittonia, 3:212. 1897.
H. pabulare A. Nels., Proc. Biol. Soc. Wash. 15:185. 1902.
H. utahense Rydb., Bull. Torrey Bot. Club, 34:424. 1907.
H. pabulare var. *rivulare* Williams. Ann. Mo. Bot. Gard. 21:344. 1934.
H. mackenzii var. *pabulare* (A. Nels.) Kearney and Peebles, Journ. Wash. Acad. Sci. 29:485. 1939.
H. boreale var. *typicum* Rollins, Rhodora, 42:232. 1940.
H. boreale var. *utahense* (Rydb.) Rollins, Rhodora. 42:232. 1940.
H. mackenzii var. *fraseri* B. Boi., Canad. Field-Nat. 65:20. 1951.

Distribution: In grasslands or on sagebrush slopes in the lowlands, to open fields or woodlands in the mountains. British Columbia to Alberta, south through Idaho, Montana, and North Dakota to Arizona and New Mexico. Also in eastern and central Nevada. It merges in the north with the ssp. *mackenzii*.

Representative specimens:

ARIZONA: Apache Co., Salahkai Mesa, *Deaver*, s.n., 7 August 1952 (ARIZ); Navajo Co., 15 mi. S.E. of Snowflake, *Hevly* s.n., 26 June 1962 (UT, ARIZ): North Base of Black Mesa, *Shreve 8968*, 21 June 1939 (ARIZ, UT, COLO).

BRITISH COLUMBIA: Yoho Park on Mt. Stephen, *Ulke 175*, 2 August 1927 (MONTU); Marble Mts., *Thompson 195*, 20 June 1938 (PH).

COLORADO: Boulder Co., North of Boulder, *Bethel 4170*, 22 July 1921 (MONTU, UTC, COLO, PH). Dolores Co., T. 39 N., R. 14 W., *Ownbey 1477*, 26 August 1937 (PH, UTC, MONT). Eagle Co., Holy Cross Forest Station, *Rice 351*, 18 July 1941 (USFS). Fremont Co., South of Canon City, *Ewan 14225*, 12 June 1942 (COLO). Las Animas Co., 20 mi. northwest of Branson, *Rollins 1864*, 14 July 1937 (UTC, USFS, MONT). Mesa Co., Colorado National Monument, *Pennell 22144*, 24 June 1938 (PH); Montezuma Co., Mesa Verde Natl. Park, *Welsh 2082*, 7 June 1963 (BRY, SDU); Switchback road below Point Lookout, *Welsh 3029*, 13 June 1964 (BRY).

IDAHO: Butte Co., National Reactor Test Station, *Atwood 914*, 8 June 1967 (BRY). Custer Co., Lost River Mts., *Hitchcock 11109*, 14 August 1944 (UTC).

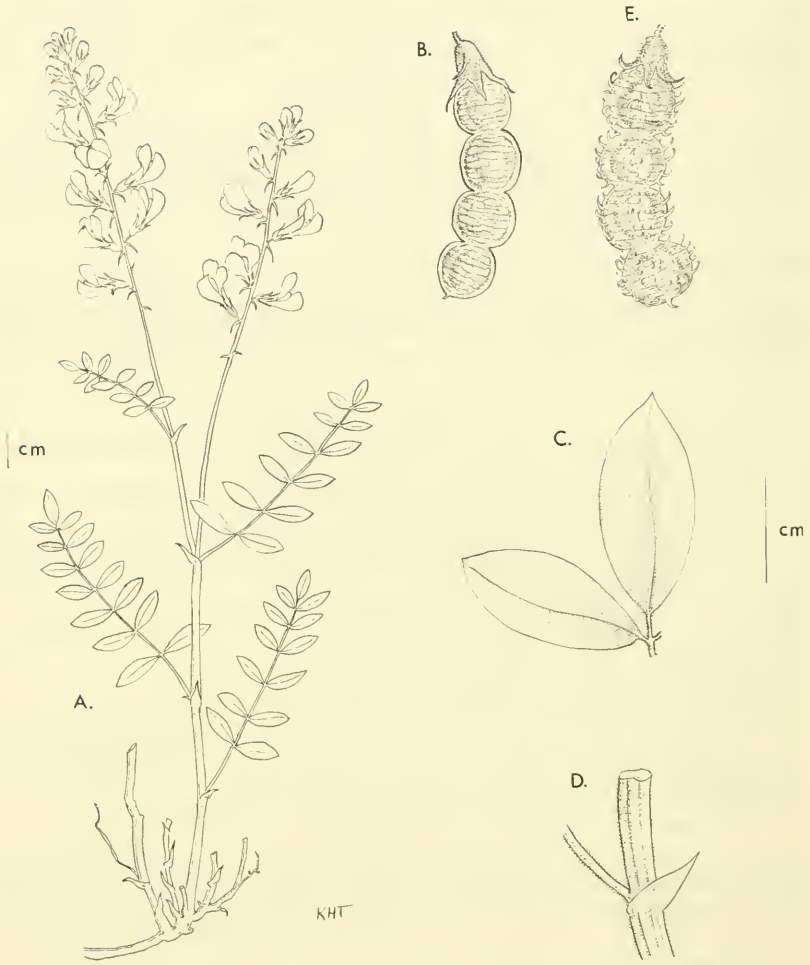

Fig. 6 *Hedysarum boreale* ssp. *boreale* var. *boreale*: A. habit sketch. B. loment. C. leaflet detail. D. stipule detail. *Hedysarum boreale* ssp. *boreale* var. *gremiale*: E. loment.

MONTANA: Gallatin Co., Gallatin Forest, Bear Creek, *Whitman 1811*, 31 July 1935 (USFS). Golden Valley Co., Northwest of Levina, *Booth 55222*, 26 June 1955 (MONT). Jefferson Co., *Moran* s.n. 23 June 1965 (BRY). Lewis and Clark Co., 25 mi. N. of Augusta, *Hitchcock 18074*, 6 July 1948 (UTC, COLO).

NEW MEXICO: Colfax Co., East of Colfax, *Goodding G143-40*, 13 June 1940 (OSC); Raton, *St. John 147*, July 1894 (UTC).

NEVADA: Elko Co., Humbolt National Forest, near Clover Creek, *Robertson 300*, 19 July 1949 (USFS).

NORTH DAKOTA: Billings Co., Medora, *Stevens 11*, 29 June 1938 (MONT). Dunn Co., R. 92, Twp. 149, *Heidenwish* s.n., 11 June 1936 (NDA).

OKLAHOMA: Cimarron Co., 2 mi. N. of Kenton, *Hess 723*, 26 May 1966 (OKL).

UTAH: Box Elder Co., Wellsville Mts., *Burke 3012*, 23 May 1932 (UTC). Carbon Co., Wellington, *Cottam 2046*, 5 June 1927 (BRY); West Tavaputs Plateau, *Maguire 18515*, 9 June 1940 (UTC, BRY); West side of Schofield Reservoir, *Welsh 6521*, 1 August 1967 (BRY). Davis Co., Mueller Park, *Brizzee* s.n., 28 April 1940 (UT). Garfield Co., Bryce Canyon, *Rollins 2453*, 7 July 1938 (USFS). Grand Co., Arches National Monument, *Welsh 1903*, 2 May 1963 (BRY). Salt Lake Co., Fort Douglas, *Brenchle* s.n., 25 May 1918 (NDA); Parley's Canyon, *Vickery 657*, 24 June 1956 (ARIZ). San Juan Co., Coon Canyon, *Moore* s.n., 4 July 1917 (PH); La Sal Creek, *Cutler 2652*, 9 July 1939 (OKL); So. of Mexican Hat, *Hitchcock 1345*, 27 June 1930 (MONT). Uintah Co.. 1 mi. West of Rainbow, *Homgren 1819*, 4 June 1965 (BRY, UTC). Wasatch Co., 12 mi. East of Soldier Summit, *Maguire 18406*, 5 June 1940. Utah Co., Bridal Veil Falls along Provo River, *Pennell 22570*, 5 July 1938 (COLO).

WYOMING: Carbon Co., 8 mi. West of Medicine Bow, *Porter 4584*, 15 June 1948 (COLO). Sublette Co., Pine Grove Ridge, *Cazier C-124*, 23 July 1931 (USFS). Teton Co., 10 mi. South of Jackson, *Rethke 3894*, 2 July 1938 (COLO).

Plants from the Wallowa mountain of Oregon, and southern British Columbia, are intermediate in several characters between ssp. *boreale* and ssp. *mackenzii*, but tend to resemble more closely ssp. *mackenzii;* thus plants which occur in these areas will be referred to on the distribution maps as the ssp. *mackenzii*.

The var. *boreale* is usually assumed to inhabit only the plains regions of Canada, and the lower mountain slopes of the Rockies. But it is also commonly found at elevations of 8000 feet or more in many areas throughout its range. Flowering occurs from early May to early August. 2N=16.

The taxon described by Rollins (1940) as *H. boreale* var. *utahense* is not recognized here as a distinct entity for several reasons. Mass collections from the type locality of the var. *utahense* yield plants which are typical of var. *boreale* and of var. *utahense* as well as intermediates between them. Plants of *H. boreale* in the pinyon-juniper woodlands of southern and eastern Utah have small leaves. These grade with plants which have larger flowers and larger leaves in more moist canyons and slopes in northern portions of the state. There appears to be no chromosomal differences between plants from the two regions.

Hedysarum boreale Nutt. ssp. *boreale* var. *gremiale* (Rollins) Northstrom and Welsh comb. nov. (Fig. 6, E.)

Hedysarum gremiale Rollins, Rhodora, 42:230. 1940.

Distribution: Dry slopes, ravines, and pinyon-juniper communities from 5000-6000 ft. elevation in the Uintah Basin of Utah.

Specimens examined:

UTAH: Uintah Co., Moenkopi Shale, Split Mt. Gorge, Dinosaur Nat. Monument, *Brotherson 787*, 15 July 1956 (BRY); West of Vernal, *Rollins 1733*, 16 June 1937 (PH, OKL Isotype). Duchesne Co., North of Myton, *Pennell 22497*, 1 July 1938 (PH).

This taxon can be distinguished from the other varieties of the ssp. *boreale* only in the fruiting stage. None of the characters discussed in Rollins' paper (1940) other than the spiny fruits can be used to separate this entity from the other members of the complex. Even the possession of spiny fruits is not infallible, because plants with short but distinct spines commonly occur in Wyoming and as far north as Alberta. It appears that this entity is just one extreme in an essentially continuous series grading from the var. *cinerascens*. However, the more abundant development of spines on the fruits of plants from the Uinta Basin indicate that the plants should be treated in some taxonomic rank. Flowering from May to July. 2N-16.

Hedysarum boreale Nutt. ssp. *boreale* var. *cinerascens* (Rydb.) Rollins, Rhodora 42:235. 1940 (Fig. 7).

Herysarum canescens Nutt., ex. T. & G. Fl. N. Am. 1;357. 1838.
Hedysarum cinerascens Rydb., Mem. N. Y. Bot. Garden. 1:257. 1900.

Hedysarum macquenzii var. *canescens* (Nutt.) Fedtschenko, Acta Hort. Petrop. 19:362. 1902 (*sic.*).
Hedysarum boreale var. *cinerascens* (Rydb.) Rollins, Rhodora. 42:234. 1940.
Hedysarum boreale var. *obovatum* Rollins, Rhodora. 42:235. 1940.
Hedysarum boreale var. *cinerascens* f. *album* B. Boi., Nat. Canad. 87:34. 1960.

Distribution: Alberta and Saskatchewan, south through Idaho and Montana to Nevada, southern Wyoming and eastern Utah. Dry banks and ravines from 5000 to 8000 feet elevation.

Representative specimens:
ALBERTA: Milk Mts., *Boivin 9502*, 26 June 1952 (OKL); E. of Waterton River,

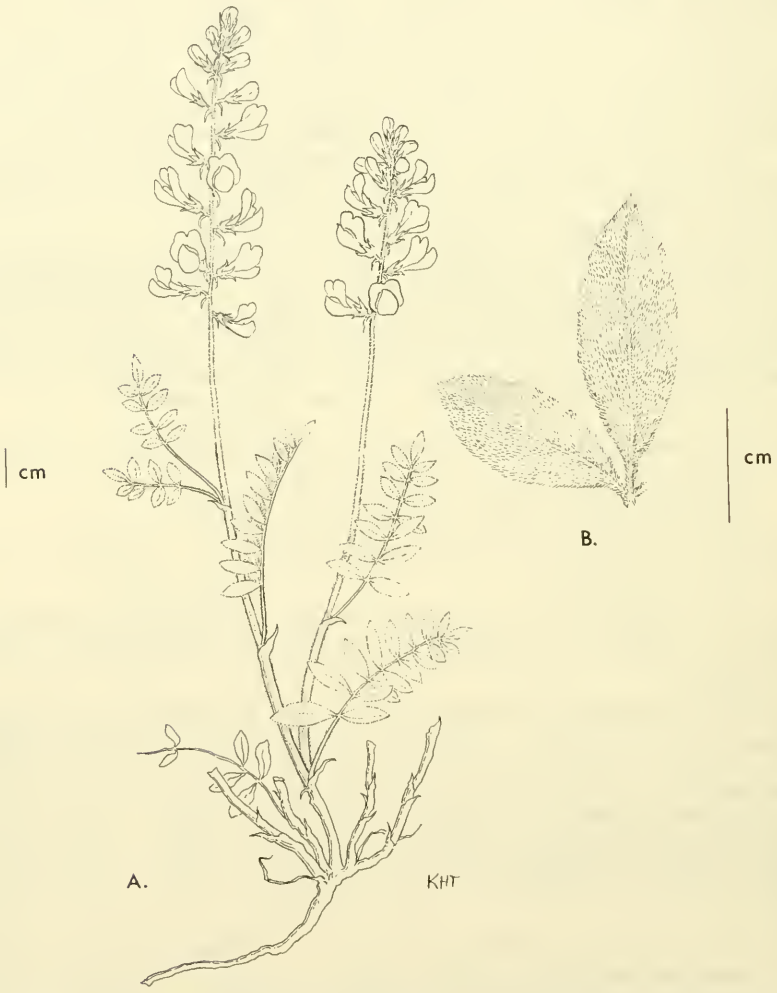

Fig. 7. *Hedysarum boreale* ssp. *boreale* var. *cinerascenss* A. habit. B. leaflet detail.

Breitung 16486, 23 July 1953 (COLO); Rosedale Trail, *Moodie 1020*, 22 June 1915 (OSC); Elkwater, *Payne 41*, 10 July 1958 (MONT).

IDAHO: Custer Co., W. of Salmon River, *Hitchcock 8989*, 15 June 1944 (MONT, UTC); W. of Clayton, *Hitchcock 10794*, 5 August 1944 (UTC). Jefferson Co., *Moran* s.n., 15 June 1967 (BRY).

MANITOBA: Near Churchill, *Brues* s.n., 6 July 1963 (OKL).

MONTANA: Broadwater Co., 7 mi. E. of Townsend, *Hitchcock 11824*, 1 July 1945 (PH, UTC). Fergus Co., Big Snowy Range, *Bamberg* s.n., 10 July 1958 (COLO); 1 mi. N. of Heath, *Hitchcock 11929* (UTC, PH, COLO). Gallatin Co., Bear Creek Road, *Wright* s.n., 8 June 1952 (MONT). Glacier Nat. Park, 3 mi. W. of E. Entrance, *Booth* s.n., 14 June 1952 (ARIZ). Lewis and Clark Co., Ear Mt. Ranger Station, *Butler D 3-12*, 1 July 1921 (USFS); Livingston Park Co., 25 mi. N. of Field, *Single*, 17 June 1936 (MONTU). Madison Co., Hammond Creek, *Hitchcock 16721*, 23 July 1947 (UTC); 6 mi. S. of Ennis, *Hitchcock 16808*, 25 July 1947 (COLO, UTC); N. W. limit of Gravelly Range, *Hitchcock 12541*, 19 July 1945 (OSC, MONT). Meager Co., 6 mi., N. W. of White Sulphur Springs, *Hitchcock 12182*, 11 July 1945 (PH, UTC, OSC, MONT).

NEVADA: Elko Co., Thorp Creek, Humbodlt Nat. Forest, *Price 168*, 25 July 1928 (USFS).

NORTH DAKOTA: Billings Co., North side of Butte, *Stevens* s.n., 3 August 1923 (NDA). Kidder Co., 8 mi. N. of Lake Williams, *Moir* s.n., 27 July 1956 (NDA). Slope Co., Saddle Butte, *Stevens* s.n., 14 June 1963 (NDA). Ward Co., 2 mi. W. of Minot, *Bare 1053*, 25 June 1968 (NDA). Wells Co., Hurdsfield, *Stevens 696*, 27 June 1943 (NDA). Williams Co., Buford, *Stevens* s.n., 21 June 1945 (NDA).

QUEBEC: Riviere Vaureal, *Louis-Marie 20871*, 28 July 1925 (PH).

SASKATCHEWAN: Location unknown, *Boivin 8796*, 11 Aug. 1951 (NDA); Battle Creek Ranger Station, Cypress Hills, *Breitung 5054*, 25 July 1947 (UTC).

UTAH: Summit Co., Elk Horn Ranger Station, *Stewart 20*, 6 June 1921 (USFS); Uintah Co., 2 mi. North of Vernal, *Porter and Rollins 5673*, 26 June 1951 (PH).

WYOMING: Big Horn Co., Big Horn Forest, Dayton-Kane Road, Dickson 250, 17 June 1932 (USFS); Red Bank, *Goodding 332*, 20 July 1901 (MONT, UTC, ARIZ); Dayton, *Stevens 38-329*, 3 July 1938 (NDA). Fremont Co., 10 mi. west of Dubois, *Porter and Rollins 5780*, 27 July 1951 (PH). Natrona Co., Near Pathfinder Reservoir, *Porter 4506*, 4 June 1948 (MONT). Park Co., 20 mi. North of Cody, *Porter 5442*, 11 July 1950 (PH, OKL). Sublette Co., 20 mi. west of Big Piney, *Payson 2617*, 9 July 1922 (PH, OSC). Teton Co., 20 mi. South of Jackson U.S. 187, *Maguire 12845*, 2 August 1935 (UTC); Elk Ranch, east side of Jackson Hole, *Reed 2315*, 13 June 1948 (OKL); Snake River bottom, *Williams 1339*, 24 July 1933 (UTC, OSC).

This taxon represents another extreme of a series grading into var. *boreale*. Its greatest development is expressed in northern and central Montana. Plants from North Dakota, eastern Utah and eastern Idaho are intermediate between var. *boreale* and var. *cinerascens*. Flowering occurs from May to early August. 2N=16.

There are several reasons for reducing the plant described by Rollins (1940) as *H. boreale* var. *obovatum* to synonomy under var. *cinerascens*. The specimen on which var. *obovatum* is based differs in no other characters from var. *cinerascens*, except for the obovate lower leaflets; but obovate leaflets are present to a greater or lesser extent in all the varieties of *H. boreale*. Also, a visit to the type locality of the entity in 1968 has failed to yield anything but plants typical of var. *boreale*. Perhaps var. *obovatum* should be regarded as merely a teratological form of the var. *cinerascens*.

Hedysarum boreale Nutt. ssp. *mackenzii* (Richards.) Welsh, Great Basin Nat. 28:152. 1968. (Fig. 8.)

Hedysarum mackenzii Richards, in Frankl. 1st. Journ. Bot. App. 745. 1823.
Hedysarum americanum var. *mackenzii* Britt., in Mem. Torrey Bot. Club. 5:202. 1894.

Hedysarum mackenzii var. *mackenzii* f. *niveum* B. Boi., Canad. Field-Nat. 65:20. 1951.

Hedysarum boreale var. *mackenzii* (Richards.) C. L. Hitchc., in Vasc. Pl. Pac. N. W. 3:275. 1961.

Stems 1.5-5 dm long, usually unbranched above, stipules pale tan, or white-translucent with brown streaks; flowers 5-20, 15-26 mm long, usually purple, occasionally pink or pale pink; racemes compact, 2-10 cm long; leaflets usually green and glabrous above, grayish-green and pubescent below; articles 3-8, margins of articles and reticulations often black pigmented.

Distribution: Alaska to Newfoundland, south of northeast Oregon, and east through southern British Columbia, to Quebec, and also in eastern Siberia.

Representative specimens:

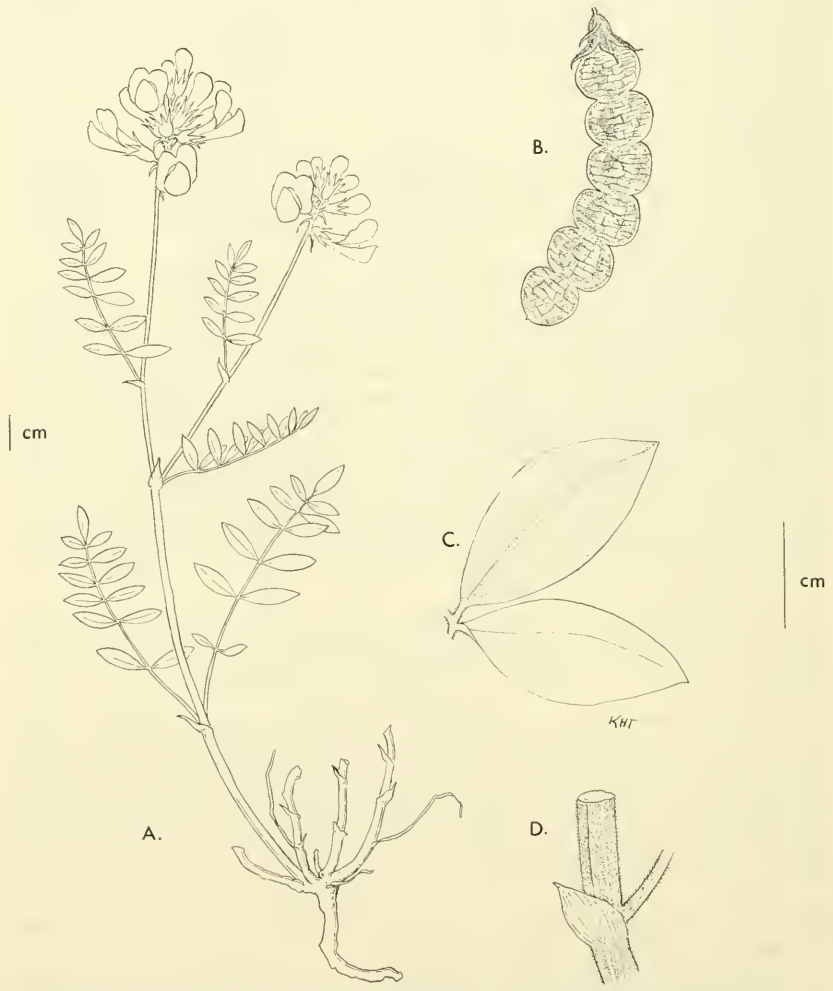

Fig. 8 *Hedysarum boreale* ssp. *mackenzii*. A. habit sketch. B. loment. C. leaflet detail. D. stipule detail.

ALASKA: Bering Strait District, *Viereck 4409*, 13 July 1960 (COLO); Mile 225 Richardson Highway, *Welsh 5041*, 2 August 1965 (BRY); Mount McKinley National Park, *Welsh 4834*, 21 July 1965 (BRY); Mile 217.3 Richardson Highway, *Williams 1273*, 22 July 1965 (OSC, BRY).

ALBERTA: Vicinity of Banff, *Brown 75*, 8 June 1906 (PH); Jasper National Park, *Davis 5082*, 22 July 1962 (BRY); North Fork Belly River, *Shaw 343*, 4 July 1967 (BRY); Mt. Castleguard, *Strock* s.n. 29 August 1930 (UTC, PH); South of Peyto Lake, *Weber 2429*, 12 July 1941 (COLO).

BRITISH COLUMBIA: Vicinity of Field, *Brown 538*, 16 July 1906 (PH); North end of Azouzetta Lake, *Calder 14022*, 4 August 1954 (OSC); 16 miles south of Lillooet, *Calder 17572*, 18 June 1959 (OSC); Halfway River, *Henry 9*, 4 July 1931 (PH); Summit Lake, *Welsh 5447*, 22 June 1966 (BRY).

MANITOBA: Churchill, *Cope* s.n., 10 July 1934 (PH); Fort Churchill, *Gillett 1913*, 30 June 1948 (OKL); Limestone river banks near Gillam, *Shofield 1099*, 12 July 1950 (COLO).

NORTHWEST TERRITORIES: Opposite Fort Simpson, *Cody 8466*, 30 June 1955 (ARIZ); Moraine Point, Great Slave Lake, *Lewis 479*, 30 June 1951 (COLO, OKL); Franklin Expedition, Collector unknown (PH, Isotype); Cambridge Bay, *Stephens 1004*, 10 July 1962 (OKL).

OREGON: Union Co., half mile north of east Eagle Creek Falls, *Head 1045*, 30 June 1957 (OSC). Wallowa Co., Wallowa Mts., *Cusick 3694*, 9 August 1911 (OSC); Hurricane Creek, *Head 127*, 29 July 1951 (BRY); Hurricane Creek Forest Camp, *Maguire 26687*, 19 July 1946 (COLO, UTC, ARIZ); Hurricane Creek trail about a half mile south of Falls Creek, *Mason 5718*, 26 August 1962 (OSC); Border of Ice Lake, *Mason 6461*, 8 August 1963 (OSC); Wallowa Forest, *Reid 738*, 27 July 1938 (USFS).

QUEBEC: Ungava Bay, *Bonde 283*, 27 July 1948 (COLO).

SASKATCHEWAN: Near Bear Creek, *Brown 909*, 14 June 1908 (PH).

YUKON TERRITORY: Mile 1019, Alaska highway, *Welsh 4056*, 9 June 1965 (BRY); Mile 114.7 Dawson highway, *Welsh 5560*, 25 June 1966 (BRY).

H. mackenzii is essentially restricted to rocky slopes, roadsides, gravel bars, sandy places and other areas which are in early stages of succession. The plants occasionally occur in tundra and open woodlands. Flowering takes place from early June to August. 2N=16.

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A SURVEY OF THE HELMINTH PARASITES OF CATTLE AND SHEEP IN UTAH VALLEY[1]

J. Carl Fox[2], Ferron L. Andersen, and Keith H. Hoopes

Introduction

Very little information is available on the prevalence of gastrointestinal helminths in domestic animals in Utah. Hammond and Hamilton (1941) reported 3 genera of parasitic helminths which they observed in sheep in the vicinity of Logan, Utah, and Andersen, Hoopes, and Fox (1969) indicated 7 genera of helminths in sheep at Provo, Utah. Apparently no other published information is available on the incidence of these parasites in domestic animals in the Utah area.

Studies were conducted at Brigham Young University during 1967 through 1969 to determine the incidence and distribution of helminth parasites in cattle and sheep in Utah Valley, Utah County, Utah. This information was necessary in order to assess the importance of parasitological problems to the animal industries in the intermountain area.

Meteorologic data were obtained to indicate the relationship of the climate in the central Utah area to the presence of gastrointestinal nematodes in domestic ruminants.

Materials and Methods

Fecal samples were collected from 209 cattle at 14 locations and from 351 sheep at 10 locations in Utah Valley. Sampling areas within the valley are indicated on Fig. 1. Fresh feces were taken directly from some animals, while other samples were obtained from the pasture as soon as possible after the animals had defecated. The samples were taken to the laboratory for subsequent examination.

The number of helminth eggs per gm (EPG) of feces in each sample was determined by using a modified McMaster sugar flotation technique. This consisted of mixing 2 gm of feces with 28 ml of 50% Sheather's sugar solution. The feces-Sheather's mixture was crushed through a tea strainer into a 70 ml evaporating dish to remove the fibrous material. A portion of the mixture was immediately transferred to a McMaster counting chamber for microscopic examination with a Swift SRL binocular microscope equipped with 10 X wide-field oculars and using the 10 X objective.

Cestode eggs were identified in the McMaster chambers by their specific morphological characteristics. Since eggs of trematodes do

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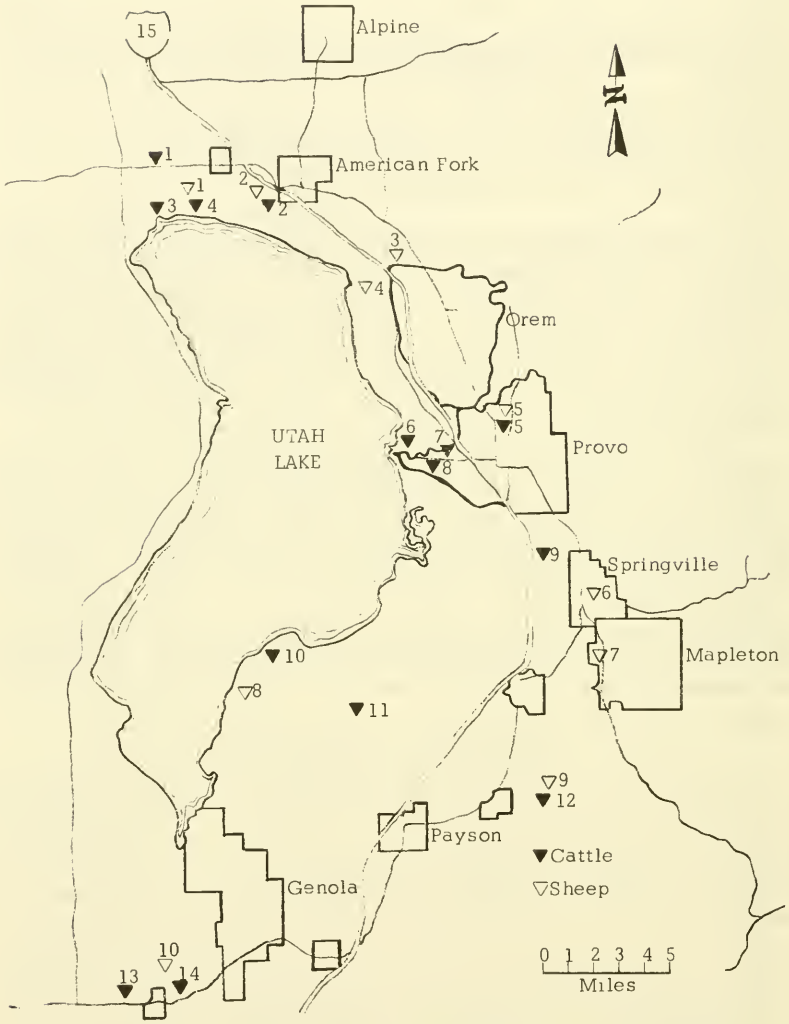

Fig. 1. Map of Utah Valley showing sampling areas where cattle and sheep were surveyed for gastrointestinal parasites.

not float in Sheather's solution, it was necessary to use sedimentation techniques on the collected feces to detect them.

Sedimentation was accomplished by washing a portion of the fecal sample through a piece of gauze into a 60 mm petri-dish and then adding water until the dish was full. The mixture was allowed to sedimentate, and the supernatant was carefully poured off. This latter process was repeated twice. The remaining sediment was then examined for the presence of fluke ova with a Bausch and Lomb

stereo-zoom dissecting microscope equipped with 10 X wide-field oculars and a 2 X auxiliary lens.

In addition to the examinations for helminth eggs, portions of the fecal samples were placed in 90 mm petri-dishes containing water-saturated paper pads for the purpose of cultivating infective larvae to be used for subsequent identification of parasitic nematodes. Feces were incubated at 30 C and 100% relative humidity for 7 days, during which time the dish covers were removed every 2 days for aeration. If necessary additional tap water was added at that time to maintain the high humidity.

After incubation the larvae were isolated from cultures by the standard baermannization technique (Baermann, 1917). Each sample was baermannized in a 90 mm funnel fitted with a small piece of rubber tubing with an attached hose clamp. The feces were put in the funnel onto a piece of cellulose tissue (Kimwipes) suspended by a ¼ in. mesh wire screen. Water was added until it covered the feces, and the sample was then allowed to stand for 6-8 hrs. at room temperature (approximately 25 C). If nematode larvae were present they passed through the cellulose tissue and settled into the stem of the funnel. After the alloted time approximately 15 ml of fluid were withdrawn from the funnel into a centrifuge tube. The mixture was stored at 4 C until larval identifications were made. At that time the supernatant was aspirated off from each sample, and a drop of fluid was placed on a microscope slide. This was either heated over a low flame or a drop of Lugol's solution was added to kill any larvae present. A cover glass was placed over the drop, and the slide examined under 10 X or 40 X magnification for identification of larvae. Third-stage larvae were identified by correlating the measurements for the total length of the larvae with the length of their sheath tails. Genera, or species whenever possible, were determined from the tables of larval measurements compiled by Dikmans and Andrews (1933), Keith (1953), Hansen and Shivnani (1956), Whitlock (1960), Soulsby (1965), and Levine (1968).

As a futher indication of the parasites in cattle and sheep in the valley, postmortem examinations were periodically made on animals killed at local abattoirs or brought to animal byproduct plants. The viscera of these animals were examined macroscopically for internal helminths, and representative sections of viscera were brought to the laboratory for further microscopic examination. All parasitic helminths detected were identified from descriptions provided by Whitlock (1960), Soulsby (1965), and Levine (1968). Helminth eggs present in feces from necropsied animals and larvae cultured from any of these same samples were identified as described above.

Weather data were collected during 1967 and 1968 to obtain an indication of the type of climate that characterizes the central Utah area. These data were obtained from a weather station located in southwest Provo, Utah. Daily maximum and minimum temper-

Table 1. Results of egg counts from cattle feces and nematode larval cultures.

Area no.	Number samples collected	Nematodes					Trematodes	Cestodes
		Egg counts				Larval cultures		
		Percent positive	EPG[1]			Percent positive	Percent positive	Percent positive
			Max.	Min.	Mean.			
1	12	41.7	250	0	50	91.7	ND[2]	00.0
2	6	33.3	50	0	17	100.0	ND	00.0
3	9	11.1	50	0	6	55.6	00.0	00.0
4	8	12.5	50	0	6	62.5	00.0	00.0
5	39	53.8	850	0	79	ND	ND	05.1
6	14	71.4	200	0	82	92.9	14.3	00.0
7	10	50.0	50	0	25	60.0	ND	00.0
8	17	00.0	0	0	0	41.2	ND	00.0
9	9	33.3	100	0	22	88.9	33.3	00.0
10	9	88.9	50	0	44	88.9	00.0	00.0
11	22	81.0	400	0	68	81.0	ND	00.0
12	33	00.0	0	0	0	12.1	ND	00.0
13	9	55.6	1750	0	239	100.0	00.0	33.3
14	12	75.0	100	0	50	66.7	ND	00.0

[1]Eggs per gram of feces.
[2]Not determined.

atures were recorded with maximum and minimum thermometers in a standard weather shelter, and daily precipitation was measured with a nonrecording rain gauge.

Results

Survey of parasites in cattle

Examination of fecal samples from cattle showed that 149 (71.3%) of 209 animals had helminth parasites. Table 2 gives the number of samples collected at each location; percent positive, maximum, and minimum, and mean egg counts; percent positive larval cultures; and percent parasitized by trematodes and cestodes. Mean EPG counts ranged from 0-239, with 1750 being the highest count observed. The highest percentage of cattle at any location with positive egg counts was 88.9% (area 10), whereas all animals at 2 locations (areas 2 and 13) were shown to harbor nematode parasites by larval culture methods. Cattle at only 6 locations were examined for trematode infections, with flukes being found in animals at 2 of those locations (areas 6 and 9).

Table 2. Helminth parasites identified in 209 cattle by egg or larval examinations.

Parasites identified	Total animals parasitized	Percent animals parasitized	Percent areas where found
Strongyloides papillosus	45	21.5	71.4
Haemonchus placei	20	9.6	64.3
H. contortus	24	11.0	57.1
Ostertagia ostertagi	27	12.9	78.6
Cooperia spp.	28	13.4	50.0
C. oncophora	48	23.0	85.7
Oesophagostomum radiatum	34	16.3	64.3
Bunostomum phlebotomum	3	1.4	14.3
Trichostrongylus spp.	35	16.7	78.6
Nematodirus spp.	1	0.5	7.2
Moniezia benedeni	4	1.9	14.3
M. expansa	1	0.5	7.2
Fasciola hepatica[1]	5	8.6	33.3

[1]Data represent only six sampling areas.

Parasites identified from cattle fecal examinations are listed in Table 2, which shows number and percent of animals parasitized by each species identified and the percent of sampling areas where each parasite was found. Ten genera of helminths were identified in cattle, with *Cooperia oncophora* being found in more animals and at more locations than any other parasite identified.

Survey of parasites in sheep

Examination of sheep fecal samples showed that 315 (89.7%) of 351 animals had helminth parasites. Table 3 gives the number of

Table 3. Results of egg counts from sheep feces and nematode larval cultures.

Area no.	Number samples collected	Nematodes					Trematodes	Cestodes
		Egg counts				Larval cultures		
		Percent positive	EPG[1]			Percent positive	Percent positive	Percent positive
			Max.	Min.	Mean			
1	9	66.7	900	0	311	100.0	44.4	00.0
2	14	92.8	3400	0	1379	100.0	ND[2]	00.0
3	13	61.5	550	0	112	100.0	ND	00.0
4	10	80.0	550	0	150	ND	ND	10.0
5	162	66.9	6700	0	694	73.1	ND	14.8
6	7	85.7	550	0	150	100.0	ND	00.0
7	20	100.0	1750	50	735	100.0	ND	05.0
8	14	92.8	2700	0	636	100.0	00.0	07.1
9	88	81.8	3200	0	199	94.3	ND	01.1
10	14	100.0	1400	50	507	100.0	ND	00.0

[1]Eggs per gram of feces.

[2]Not determined

samples collected at each location; percent positive, maximum, minimum and mean egg counts; percent positive larval cultures; and percent parasitized by trematodes and cestodes. Mean EPG counts ranged from 150-1379, with 6700 being the highest count observed. All animals examined at 2 locations (areas 7 and 10) were shown to be parasitized as assessed by egg counting techniques, whereas all animals examined at 7 locations (areas 1, 2, 3, 6, 7, 8 and 10) were positive using larval culture methods. Sheep at only 2 locations were examined for trematode infections, with flukes being found in animals at 1 of these locations (area 1).

Parasites identified from sheep fecal examinations are listed in Table 4, which shows number and percent of animals parasitized by each parasite identified and the percent of sampling areas where each parasite was found. Twelve genera of helminths were identified in sheep with *Trichostrongylus* spp. being found in the most animals and at 90% of the sampling sites. *Ostertagia circumcincta* and *Nematodirus* spp. were also observed at 90% of the sampling areas.

Distributions of all helminths found by fecal examinations of cattle and sheep within Utah Valley are shown in Table 5. Locations of sampling areas are indicated in Fig. 1, referred to previously.

Additional parasites not listed in Tables 2 and 4 which were found by necropsy were *Thysanosoma actinoides*, found in 2 of 34 sheep examined, and *Echinococcus granulosus*, found in 11 of 34 sheep.

Meteorologic measurements

Mean monthly maximum, minimum, and mean temperatures, and mean monthly precipitations measured in Utah Valley for the

Table 4. Helminth parasites identified in 351 sheep by egg or larval examinations.

Parasites identified	Total animals parasitized	Percent animals parasitized	Percent areas where found
Strongyloides papillosus	123	35.0	70.0
Haemonchus contortus	185	52.7	80.0
Ostertagia circumcincta	115	32.8	90.0
Cooperia spp.	9	02.6	30.0
Cooperia oncophora	35	10.0	80.0
Oesophagostomum columbianum	24	06.8	50.0
Bunostomum trigonocephalum	14	04.0	20.0
Trichostrongylus spp.	229	65.2	90.0
Nematodirus spp.	108	30.8	90.0
Chabertia ovina	121	34.5	80.0
Trichuris ovis	6	01.7	20.0
Moniezia benedeni	28	08.0	60.0
Fasciola hepatica[1]	4	23.5	50.0

[1]Data represent only two sampling areas.

Table 5. Distribution of helminth parasites within Utah Valley by sampling areas.

Parasites identified	Helminths of cattle														Helminths of sheep									
	Sampling area														Sampling area									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1	2	3	4	5	6	7	8	9	10
Strongyloides papillosus	*	*		*		*	*	*	*	*	*		*		*	*	*		*	*	*	*	*	*
Haemonchus placei	*	*				*	*		*	*	*		*	*										
H. contortus	*				*	*	*		*	*	*		*	*	*	*			*	*	*	*	*	*
Ostertagia ostertagi	*		*		*		*	*	*	*	*	*	*	*										
O. circumcincta															*	*	*		*	*	*	*	*	*
Cooperia spp.	*		*		*	*				*	*			*		*	*		*	*				
C. oncophora	*		*		*	*	*	*	*	*	*	*	*	*	*	*	*		*	*		*	*	*
Oesophagostomum radiatum	*		*		*			*	*	*	*	*	*	*										
O. columbianum																	*		*		*	*	*	
Trichostrongylus spp.	*	*	*		*	*	*	*	*	*	*	*	*		*	*	*		*	*	*	*	*	*
Nematodirus spp.													*			*	*	*	*	*	*	*	*	*
Bunostomum phlebotomum	*																							
B. trigonocephalum																			*			*		
Chabertia ovina															*	*	*		*		*	*	*	*
Moniezia benedeni					*								*					*	*		*	*	*	
M. expansa					*																			
Fasciola hepatica						*			*						*							*		
Trichuris ovis															*				*					

years 1967 and 1968 are given in Table 6. These data are represented by bioclimatographs shown in Figs. 2 and 3 for those years, respectively. Each bioclimatograph contains a closed curve formed from plots of mean monthly temperatures and total monthly precipitations as illustrated by Levine (1965). Optimum conditions for development and survival of the free-living stages of *Haemonchus* and *Ostertagia* species are delineated by solid and broken lines, respectively. The bioclimatographs show that weather conditions in Utah Valley were optimum in the months of May 1967, April 1968, and August 1968 for the development of *Ostertagia*, while development of *Haemonchus* was favored only in August 1968. Average monthly precipitation for 1967 was 27.42 mm (1.04 in), or about normal for this area, and 45.97 mm (1.81 in) for 1968. The higher amount received during the latter year was accounted for largely by more than average rainfall during April and December 1968 (Table 6).

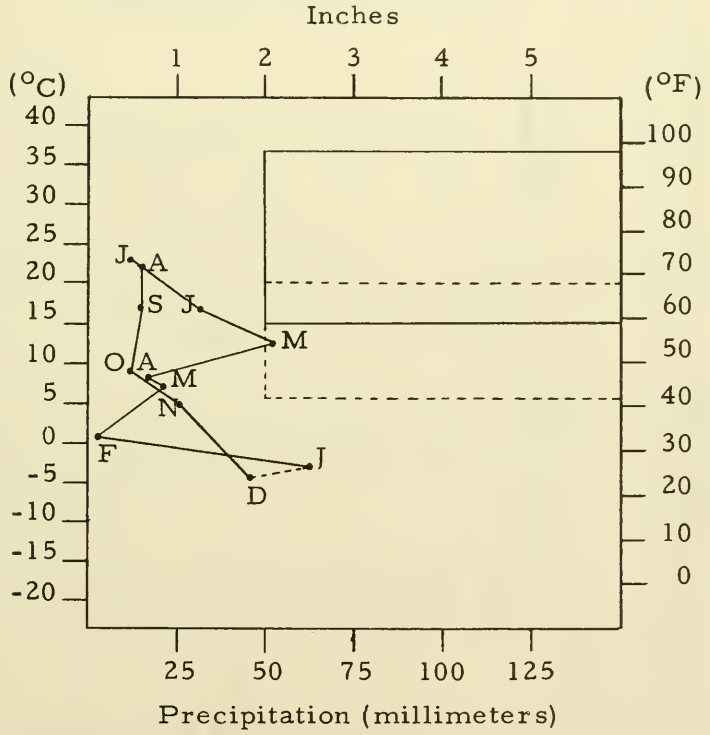

Fig. 2. Bioclimatograph of Utah Valley climate for 1967 in relation to the ecology of gastrointestinal helminths of ruminants. Optimum pasture conditions for *Haemonchus* (solid lines): 5 cm total monthly precipitation and 15-37 C mean monthly temperature. Optimum pasture conditions for *Ostertagia* (broken lines): 5 cm total monthly precipitation and 6-20 C mean monthly temperature.

Table 6. Mean monthly temperatures in a standard weather shelter and total monthly precipitations for the years 1967 and 1968.

Month	1967				1968			
	Mean monthly temperatures (°C)			Precipitation (millimeters)	Mean monthly temperatures (°C)			Precipitation (millimeters)
	Max.	Min.	Mean		Max.	Min.	Mean	
January	3.3	-9.2	-2.9	62.5	2.5	-13.2	5.3	9.9
February	7.4	-6.4	0.5	2.5	9.4	-3.6	2.9	49.0
March	14.4	-1.7	6.4	21.6	12.3	-1.4	5.5	43.2
April	15.6	-0.2	7.7	16.3	14.5	0.1	7.3	101.9
May	20.9	3.4	12.2	54.1	22.0	3.8	12.9	37.9
June	25.8	7.8	16.8	32.0	28.8	8.7	18.7	39.4
July	33.3	12.6	22.9	12.5	32.6	11.8	22.2	13.2
August	33.0	11.8	22.4	14.5	28.0	9.7	18.8	56.1
September	27.6	6.4	17.0	15.2	25.4	3.6	14.6	5.6
October	17.9	-0.3	8.8	11.9	19.2	0.2	9.7	34.5
November	13.3	-3.4	5.0	27.2	9.6	-2.1	3.8	37.3
December	1.2	-10.1	-4.4	46.2	4.2	-9.3	-2.6	123.6

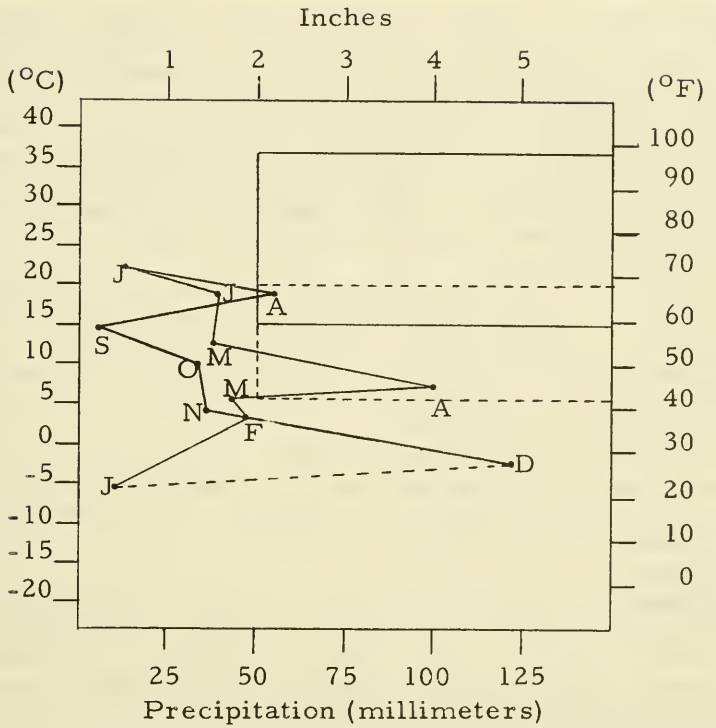

Fig. 3. Bioclimatograph of Utah Valley climate for 1968 in relation to the ecology of gastrointestinal helminths of ruminants. See Fig. 2 for explanation.

Discussions and Conclusions

The survey of parasites herein reported showed that 71.3% of 209 cattle and 89.7% of 351 sheep at various locations within the valley were parasitized by gastrointestinal helminths. The levels of parasitism in cattle were quite low (Table 1), with mean EPG counts ranging from 0-239. The only cattle found to harbor gastrointestinal helminths in this study were beef cattle which were allowed to graze on irrigated pastures, whereas all examinations of dairy cattle kept in feed lots were negative. Levine and Aves (1956) and Zimmerman and Hubbard (1961) also observed that helminth parasitism was usually lower in dairy cattle, which probably relates to their being kept on pasture only a minimum amount of time.

Even though the levels of parasitism by helminths in cattle did not indicate a serious problem, nevertheless, there were 10 genera of helminths identified in them (Table 2). The most common species of worm found in cattle in the valley was *C. oncophora.* This parasite is also common in such states as Georgia (Andrews, Jones and Sippel, 1953; Becklund, 1959, 1962) and Florida (Beck-

lund, 1961a). In addition, Tunnicliff (1932) reported massive infections by this parasite in cattle at Bozeman, Montana. Other helminths found in this current study correspond closely to those mentioned in reports of parasites in cattle from Arizona and New Mexico by Becklund and Allen (1955, 1958) and from Arizona by Dewhirst, Trautman and Pistor (1958). Many of the same genera identified in the present study were also reported in Montana cattle by Jacobson and Worley (1969). Some of these authors, however, also found *Capillaria, Setaria,* or *Dictyocaulus,* none of which were encountered in this study.

In contrast to the results from cattle, the levels of parasitism in sheep were considerably higher (Table 3). Sheep from 10 locations in the valley had mean EPG counts ranging from 150-1379. Several animals located at the BYU farm (area 5) had EPG counts above 2000, and at least 2 animals, 1 of which died (Andersen, et al., 1969), had clinical infections.

The incidence of nematodes identified in sheep around the valley varied slightly from the incidence in animals at the BYU farm (area 5). At all areas other than the farm, *Trichostrongylus* spp. were most prevalent, while at the BYU farm *H. contortus* was more common.

Chabertia ovina was identified in 23.5% of BYU sheep and 43.9% of sheep at the other locations within the valley. This parasite was observed in Montana sheep by Seghetti (1949), but was not encountered there by Jacobson and Worley (1969). It was reported by Swales (1940) as being very common in Canada, and was observed in sheep in Georgia by Cooperrider (1952) and Becklund (1961b).

Ostertagia circumcincta was quite common in sheep in the valley with an incidence of 32.8% of those animals examined. *Ostertagia* spp. were found consistently in Montana cattle by Seghetti (1949), Worley and Sharman (1966), and Jacobson and Worley (1969) and in sheep in California by Baker, et al. (1954).

Two species of cestodes were identified in cattle and sheep by fecal examinations. These were *Moniezia benedeni* and *M. expansa. Moniezia benedeni* was most prevalent in both cattle and sheep, with the highest incidence (14.8%; 24 animals) in sheep at the BYU farm. Porter (1953) summarized reports from 9 states and indicated that cattle were most often parasitized with *M. benedeni* and sheep with *M. expansa.* Results in this study differed, since *M. expansa* was found only in cattle, whereas *M. benedeni* was observed in 4 cattle and 28 sheep surveyed. Swales (1940) and Becklund (1961b) reported *M. expansa* in Canada and Georgia, respectively, but did not list *M. benedeni* in sheep from those areas.

Fasciola hepatica was found in 2 of 6 herds of cattle examined and 1 of 2 herds of sheep. Interviews with abattoir owners and meat inspectors in the valley revealed that up to 50% of livers from cattle are routinely condemned because of fluke infections. Indi-

cations are that liver flukes probably constitute a serious economic problem in the valley.

The distribution of helminth parasites identified in both cattle and sheep (Table 5) showed that *S. papillosus*, *H. contortus*, *C. oncophora* and *Trichostrongylus* spp. were universal with respect to host and distribution throughout Utah Valley. This indicates that transmission of these parasites between cattle and sheep may be quite common in this area. Porter (1953) was able to experimentally infect either cattle or sheep with *H. contortus*, *S. papillosus* and *Cooperia* spp., and Cooperrider (1952) demonstrated that these same organisms parasitized both cattle and sheep which he surveyed in Georgia.

The most significant parasites found by limited necropsy observations were *Thysanosoma actinoides* and *Echinococcus granulosus*. *Thysanosoma actinoides* was found in the bile ducts of only 2 sheep; however, this parasite has been reported as a common parasite of sheep in Montana (Welch, 1930; Seghetti, 1949).

Intermediate stages of the dog tapeworm, *Echinococcus granulosus*, were found in the livers of 11 sheep. This parasite constitutes a serious health hazard for man because of the danger involved in becoming infected while handling diseased sheep livers or by contamination from infected dogs. Further studies need to be conducted to establish how much of a problem *E. granulosus* is in this area.

Climate was used by Gordon (1948) and Levine (1952, 1962, 1963, 1965) as a means of predicting foci of helminthiasis of domestic ruminants in various geographical regions. They found a high correlation between the incidence of gastrointestinal nematodes and the climatic conditions in certain areas. According to bioclimatographs for Utah Valley (Figs. 2 and 3), climatic conditions in this area would be unfavorable for development of ruminant nematodes. This is not the case, however, since nematode species representing 10 genera were identified in cattle and sheep in the valley. (Tables 2 and 4).

Utah Valley is located in a low rainfall region with a normal mean precipitation of approximately 25 mm per month. The fact that nematode parasites are able to develop quite well in the area suggests that factors other than rainfall and temperatures are involved in the development and transmission of these organisms. For instance, irrigation, which is a common practice in this area, is the major source of pasture water rather than precipitation. Although the amount of water put on a pasture during irrigation is difficult to measure, it is estimated that amounts comparable to 20 in. of rainfall may be added to the pasture during the irrigating season (Andersen, et al., 1969). Irrigation seems, therefore, to provide ample moisture for parasite development.

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ENVIRONMENTAL RESPONSES OF ACTIVE LIZARDS AT SARATOGA SPRINGS, DEATH VALLEY, CALIFORNIA

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Abstract.—Four species of lizards (*Uta stansburiana, Callisaurus draconoides, Cnemidophorus tigris,* and *Dipsosaurus dorsalis*) were studied at Saratoga Springs, Death Valley National Monument, California, during their seasons of activity. Effects of the environment on activity, and on seasonal and diel changes in body temperature were observed. The lizards were found to respond differently to the environmental factors of air temperature, substrate temperature, black-bulb temperature, wind, rain, and cloud cover. Temperature is the factor primarily affecting activity in all species. Seasonal acclimatization of T_b is suggested in *Uta* and *Dipsosaurus*. Diel thermal lability is shown in *Uta, Callisaurus,* and *Cnemidophorus*. The species appear to be effectively partitioned within the thermal environmental factors studied.

Introduction

In recent years there have been a number of studies treating the responses of lizards to the environment. Most of these studies have dealt largely or entirely with thermal relations. Among early studies are those of Conant (1938), Sergeyev (1939), Cowles (1941), Cowles and Bogert (1944), and Fitch (1956). More recently, students of reptilian ecology have examined various interrelationships between environmental temperatures, taxonomic groups, and body temperatures of lizards. Among these are the studies of Milstead (1957a), Ruibal (1961), and Soulé (1963). Heath (1962, 1964, 1965) has examined thermoregulation of *Phrynosoma* in some detail, and Bustard (1967) has done similar work on *Gehyra variegata.* Milstead (1957b) and Laughlin (1965) included thermal relations in their studies of competitive interactions of lizards. Miller and Stebbins (1964) presented data on environmental responses of vertebrates in Joshua Tree National Monument, California, and Brattstrom (1965) and Cunningham (1966) have presented summaries of body temperatures of various reptiles.

This study was undertaken to determine the relationship of certain components of the environment to the body temperature and activity of *Uta stansburiana, Callisaurus draconoides, Cnemidophorus tigris,* and *Dipsosaurus doralis* at Saratoga Springs, Death Valley National Monument, California. The environmental components chosen were air temperature, substrate temperature, black-bulb temperature, wind, rain, and cloud cover. Wherever possible, reactions to these components have been correlated with time of day and season. It has been made apparent, from the studies cited above, that these factors are all of major importance in the ecology of lizards, especially desert forms. I have examined the reactions of the in-

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dividual species to these components and compared reactions between species to determine whether ecological segregation has occurred.

Study Area

Location:

Saratoga Springs lies in the extreme southern portion of Death Valley National Monument, San Bernardino Co., California, at an elevation of 59.1 m. The springs are ca. 60.0 km NNW of Baker, San Bernardino Co., California; ca. 29.6 km SW of Shoshone, Inyo Co., California; and ca. 80.0 km ssw of Furnace Creek, D.V.N.M., Inyo Co., California. The study area is bounded on the west by the Amargosa River and attendant alkali flats, and on the north, south, and east by rocky ridges of the Ibex Mountains. A narrow strand of creosote desert at the northwest end of the study area connects with an extensive alluvial fan-creosote desert area to the north.

Description:

The study area consists of a spring pond fed by two constant temperature spring heads; three smaller non-impounded, constant temperature springs that drain into a three-acre, seasonally fluctuating marsh; a rim of dunes; a small alluvial fan; and the rocky ridges (Deacon, et al, mimeographed report). The dunes, alluvial fan, and to a lesser extent the ridges and dry portions of the marsh are considered in this study. The plant communities of Saratoga Springs are discussed in some detail by Bradley (1970).

Climate:

Freezing temperatures are limited to December and January, and summer temperatures regularly exceed 43.0 C. Table 1 is a summary of temperature data for the period of the study. U. S. Weather Bureau records from the station 14.4 km NNW of Baker, San Bernardino Co., Calif., the nearest weather station, recorded 1.06 cm of rain in 1967, more than half of which fell in winter and spring.

Table 1. Summary of ambient temperature at Saratoga Springs, D.V.N.M., San Bernardino Co., California, for February 1967-June 1968. Sample intervals represent first and last week in each month and the range is in parenthesis.

Sample Interval	X Max. °C	X Min. °C	X °C
1-7 February 1967	28.4 (26.7-30.0)	7.0 (4.4-8.9)	17.8 (4.4-30.0)
22-28 February 1967*	21.6 (20.0-24.0)	4.2 (1.7-7.2)	13.0 (1.7-24.0)
1-7 March 1967*	24.3 (16.6-28.9)	5.8 (2.2-9.4)	14.8 (2.2-28.9)
25-31 March 1967*	23.4 (17.8-28.4)	8.9 (2.6-12.8)	16.3 (2.6-28.4)
1-7 April 1967*	21.8 (16.2-26.1)	7.5 (4.0-10.6)	14.7 (2.0-26.1)
21-27 April 1967	34.1 (28.3-41.7)	11.5 (8.3-15.5)	24.4 (8.3-41.7)
28 April-4 May 1967	34.3 (30.0-39.3)	14.1 (11.2-20.0)	25.2 (11.1-39.3)

Table 1. (Continued)

Sample Interval	X Max. °C	X Min. °C	X °C
25-31 May	32.7	17.6	25.1
1967*	(27.3-37.3)	(11.1-20.0)	(11.1-37.3)
1-7 June	31.8	15.7	23.9
1967*	(26.0-35.0)	(11.7-17.8)	(11.7-35.0)
24-30 June	42.4	24.0	33.0
1967*	(40.5-46.2)	21.1-28.3)	(21.1-46.5)
1-7 July	45.1	27.9	36.6
1967*	(41.1-48.4)	(23.3-31.6)	(23.3-48.4)
25-31 July	43.0	28.6	35.2
1967*	(39.3-45.5)	(26.7-30.6)	(26.7-45.5)
1-7 August	43.0	27.5	35.3
1967*	(40.6-45.0)	(24.4-30.6)	(24.4-45.0)
25-31 August	41.8	25.5	32.8
1967	(37.8-45.0)	(23.3-27.8)	(23.3-45.0)
2-6 September	44.8	28.3	37.5
1967‡	(41.1-48.8)	(24.5-32.2)	(24.5-48.8)
24-30 September	30.3	26.2	30.1
1967	(16.0-37.3)	(23.8-28.8)	(16.0-37.3)
1-7 October	32.8	24.3	28.6
1967	(30.4-34.4)	(21.1-26.7)	(21.1-34.4)
25-31 October	34.1	17.5	25.6
1967	(27.8-37.3)	(12.8-18.3)	(12.8-37.3)
1-7 November	32.9	17.2	24.8
1967	(29.4-35.0)	(14.3-20.0)	(14.3-35.0)
24-30 November	18.3	7.3	12.9
1967	(12.7-21.1)	(4.4-10.0)	(4.4-21.1)
1-7 December	17.0	5.6	11.9
1967	(14.4-21.1)	(3.3-17.7)	(3.3-21.1)
25-31 December	18.3	1.3	9.7
1967*	(15.0-21.1)	(-2.2-15.6)	(-2.2-21.2)
1-7 January	14.0	-2.4	5.8
1968*	(13.2-15.0)	(-5.6-2.8)	(-5.6-15.0)
25-31 January	22.1	7.3	14.6
1968	(18.9-24.5)	(3.4-12.8)	(3.4-24.5)
1-7 February	24.8	5.8	15.2
1968	(21.6-27.6)	(4.0-8.3)	(4.0-27.6)
24-29 February	34.3	15.0	25.3
1968‡	(32.2-36.2)	(10.6-16.6)	(10.6-36.2)
1-7 March	31.6	12.7	21.4
1968	(24.4-35.5)	(9.6-15.5)	(9.6-35.5)
25-31 March	29.4	10.8	20.3
1968*	(27.8-32.1)	(7.2-14.4)	(7.2-32.1)
1-7 April	37.0	15.2	26.2
1968	(35.0-39.4)	(13.7-21.1)	(13.7-39.4)
24-30 April	45.5	17.6	31.6
1968	(43.2-49.4)	(15.5-20.4)	(15.5-49.4)
1-7 May	46.2	22.0	34.4
1968	(41.6-50.4)	(18.3-25.0)	(18.3-50.4)
25-31 May	39.4	19.5	29.3
1968*	(34.0-41.8)	(16.7-23.3)	(16.7-41.8)
1-7 June	35.9	20.6	28.0
1968*	(27.2-42.7)	(15.0-26.7)	(15.0-42.7)
24-30 June	42.3	24.3	33.4
1968*	(38.3-45.6)	(21.7-27.2)	(21.7-45.6)

*Records from U.S. Weather Bureau Station, 14.4KM NNW, Baker, San Bernardino Co., California.
‡One day's minimum temperature missing.

Material and Methods

Most lizards were collected by shooting with .22 caliber "dust shot." Noosing or hand capture was used to a lesser extent. Collections were made during at least one day per month from February 1967 to June 1968, except May, June, November, and December 1967.

Data recorded included the following: 1) species, 2) sex, 3) body temperature (T_b),4) substrate temperature (T_s),5) air temperature (T_a),6) wind speed taken within 5 cm of the substrate, 7) time of day in PST, 8) habitat, and 9) black-bulb temperature (T_{BBT}). Black-bulb temperatures were not taken during the second half of the study. All other temperatures were taken as outlined by Brattstrom (1965), except in June 1968 when a standard mercury thermometer was used to measure T_s because of the 50 C limit imposed by the Schultheis thermometer. Wind speed was measured with a hand-held Dwyer wind meter calibrated in mph. Measurements were made as close as possible to the site of capture and in the order 1) T_b, 2) T_a, 3) T_s and T_{BBT}, and 4) wind speed.

Records of general ambient temperature were obtained from recording thermographs maintained in the field. The records obtained were not complete, however, due to occasional machine failure. Missing data have been supplemented by use of U.S. Weather Bureau records from the station 14.4 km NNW Baker, Calif.

All quantitative data for each lizard were analyzed statistically on an IBM 1130 computer. Statistical values used in this study represent the 5% level of confidence and means are presented $\pm$ one standard error of the mean unless stated otherwise.

Results

Uta stansburiana:

The side-blotched lizard is active within a wide range of environmental conditions at Saratoga Springs. Temperature exerts a primary control over activity of *Uta*, and other factors seem of importance only so far as they affect temperature.

Uta stansburiana at Saratoga Springs have been collected over a wide range T_a and T_s (Table 2). Low temperature values recorded here are somewhat lower than those listed by Brattstrom (1965). T_b of *Uta* correlates more closely to T_a than T_s (T_a, $r = .598$, $df = 90$, $P < .01$; T_s, $r = .396$, $df = 90$, $P < .01$). Table 2 indicates $\bar{X}$ that mean body temperature (MBT) is closer to $\bar{X}$ T_S than $\bar{X}$ T_a. The range of T_s is greater than that of T_b, especially at higher temperatures, and is probably the reason for the higher T_b: T_a correlation. My observations differ from those of Soulé (1963) who found no correlation between T_b and T_a for *Uta* from Baja California, Mexico.

T_{BBT} associated with active *Uta* ranged from 25.1 C to 47.6 C ($\bar{X} = 35.85 \pm .76$ C).

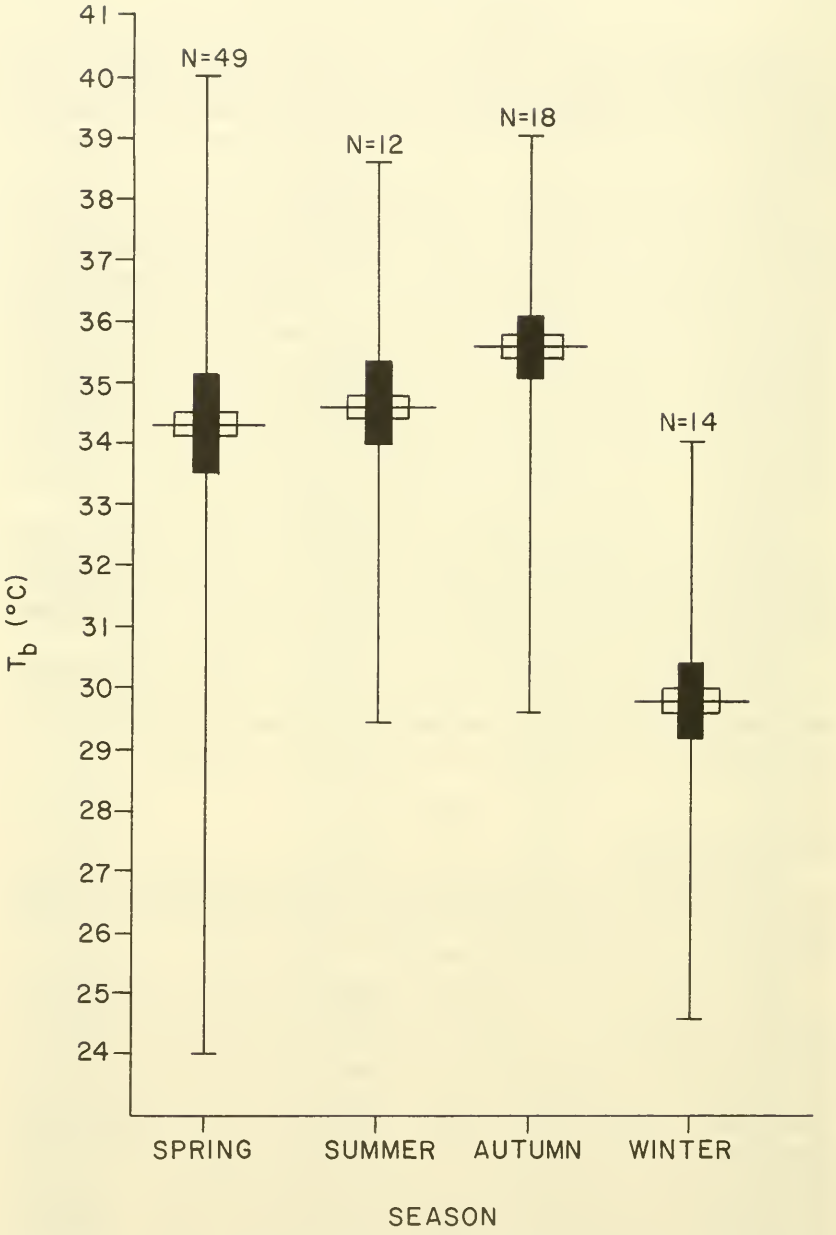

Fig. 1. A comparison, by season, of the range and mean of T_b for *Uta stansburiana* at Saratoga Springs, D.V.N.M., California. Vertical line is range; Horizontal line is X; Vertical bar is 2S; Horizontal bar is $2S_X$.

Table 2. Summary of temperature data obtained from four lizard species at Saratoga Springs, D.V.N.M., California. Mean ± 1 $S_{\bar{X}}$, range in parenthesis, and sample size.

	°C	All Parameters	♂	♀	Spring	Summer	Autumn	Winter
		N = 92	N = 55	N = 37	N = 49	N = 12	N = 18	N = 14
Uta	T_b	33.84 ± .40 (24.6-40.0)	34.31 ± .49 (24.6-40.0)	33.15 ± .67 (24.0-39.8)	34.32 ± .57 (24.0-40.0)	34.55 ± .87 (29.4-38.6)	35.61 ± .60 (29.6-39.0)	29.82 ± .77 (24.6-34.2)
Stansburiana	T_s	32.84 ± .59 (21.0-47.4)	32.13 ± .83 (21.6-44.6)	33.84 ± .87 (23.0-47.4)	34.37 ± .93 (23.0-47.4)	33.78 ± .92 (29.1-40.0)	32.68 ± 1.27 (24.4-43.1)	27.95 ± 1.33 (21.0-39.8)
	T_a	30.72 ± .45 (18.0-39.6)	30.54 ± .65 (18.0-38.6)	31.00 ± .69 (21.6-39.6)	31.75 ± .56 (22.6-39.6)	32.88 ± .77 (28.8-38.6)	31.55 ± .88 (25.6-36.4)	24.42 ± .92 (18.0-28.8)
		N = 80	N = 40	N = 40	N = 44	N = 21	N = 14	
Callisaurus	T_b	39.00 ± .40 (26.2-43.8)	38.70 ± .56 (26.2-43.2)	39.31 ± .57 (31.5-43.8)	39.49 ± .46 (32.0-43.8)	38.37 ± .96 (26.2-43.2)	38.26 ± 1.00 (30.0-42.0)	
Draconoides	T_s	42.23 ± .70 (21.8-51.0	40.67 ± .90 (26.1-49.8)	41.78 ± 1.08 (21.8-51.0)	42.30 ± .94 (21.8-51.0)	40.43 ± 1.44 (26.1-50.8)	38.41 ± 1.26 (31.4-46.2)	
	T_a	36.51 ± .49 (22.4-45.4)	36.04 ± .60 (26.8-42.8)	36.97 ± .77 (22.2-45.4)	36.52 ± .66 (22.2-42.8)	37.89 ± 1.05 (26.8-45.4)	34.61 ± .81 (29.2-40.0)	
		N = 47	N = 29	N = 18	N = 30	N = 16		
Cnemidophorus	T_b	39.72 ± .30 (34.4-42.4)	39.76 ± .38 (34.4-42.4)	39.66 ± .49 (36.0-42.4)	40.13 ± .31 (36.0-42.4)	38.80 ± .58 (34.4-42.0)		
Tigris	T_s	39.34 ± .82 (25.0-50.0)	38.88 ± .84 (30.8-49.8)	40.08 ± 1.68 (25.0-50.0)	40.11 ± 1.12 (25.0-50.0)	37.65 ± 1.06 (32.3-47.8)		
	T_a	34.99 ± .60 (25.4-44.8)	35.24 ± .69 (27.8-44.8)	34.60 ± 1.13 (25.4-43.6)	34.68 ± .79 (25.4-44.8)	35.89 ± .95 (29.8-43.6)		
		N = 44	N = 16	N = 28	N = 33	N = 11		
Dipsosaurus	T_b	40.20 ± .31 (35.2-43.2)	40.00 ± .39 (37.0-42.2)	40.31 ± .44 (35.2-43.2)	39.73 ± .36 (35.2-43.0)	41.58 ± .42 (39.0-43.2)		
Dorsalis	T_s	42.14 ± .78 (27.8-50.2)	40.94 ± 1.46 (27.8-50.2)	42.83 ± .89 (32.4-50.1)	42.27 ± .53 (27.8-50.2)	41.76 ± 1.48 (36.2-50.1)		
	T_a	37.69 ± .55 (28.2-46.8)	36.69 ± .88 (28.2-42.0)	38.26 ± .70 (28.8-46.8)	37.21 ± .68 (28.2-46.8)	39.16 ± .71 (36.4-42.6)		

My record of MBT for *Uta* (Table 2) does not appear to differ significantly from that listed by Brattstrom (1965), Cunningham (1966), or Tinkle (1967). The range is closer to Brattstrom's (1965) than to Cunningham's (1966) values for active *Uta stansburiana.* There is no significant difference between male and female *Uta* (Table 3). The MBT of *Uta* is significantly lower than the other species studied at Saratoga Springs (Table 3).

Table 3. Summary of comparison of means of temperature data from four lizard species at Saratoga Springs, D.V.N.M., California. Raw data taken from Table 2. N.S. = not significant; T = t-score; DF = degrees of freedom; P = significance level.

	Uta Stansburiana			Callisaurus Draconoides			Cnemidophorus Tigris			Dipsosaurus Dorsalis			
	T	DF	P	T	DF	P	T	DF	P	T	DF	P	
Callisaurus	9.22	170	<.01										T_b
Draconoides	9.14	170	<.01										T_s
	8.83	170	<.01										T_a
Cnemidophorus	11.76	137	<.01	1.44	125	N.S.							T_b
Tigris	5.53	137	<.01	1.00	125	N.S.							T_s
	5.62	137	<.01	1.93	125	<.05							T_a
Dipsosaurus	12.71	134	<.01	2.40	122	<.02	1.14	89	N.S.				T_b
Dorsalis	9.41	134	<.01	0.91	122	N.S.	2.48	89	<.02				T_s
	9.68	134	<.01	1.62	122	N.S.	3.32	89	<.01				T_a
	1.37	90	N.S.	0.75	78	N.S.	0.61	45	N.S.	0.53	42	N.S.	T_b
♂ : ♀	1.41	90	N.S.	1.22	78	N.S.	0.64	45	N.S.	1.10	42	N.S.	T_s
	0.48	90	N.S.	1.03	78	N.S.	0.48	45	N.S.	1.40	42	N.S.	T_a
Spring:	0.22	59	N.S.	1.05	63	N.S.	2.02	44	= .05	3.30	42	<.01	T_b
Summer	0.43	59	N.S.	1.09	63	N.S.	1.42	44	N.S.	0.29	42	N.S.	T_s
	1.20	59	N.S.	1.91	63	<.05	1.15	44	N.S.	1.99	42	<.05	T_s
Spring:	1.55	65	N.S.	1.11	56	N.S.							T_b
Autumn	1.07	65	N.S.	2.56	56	<.02							T_s
	0.18	65	N.S.	0.87	56	N.S.							T_a
Summer:	1.00	28	N.S.	0.79	33	N.S.							T_b
Autumn	0.72	28	N.S.	1.06	33	N.S.							T_s
	1.14	28	N.S.	2.46	33	<.02							T_a
Spring:	4.69	61	<.01										T_b
Winter	3.92	61	<.01										T_s
	6.77	61	<.01										T_a
Summer:	4.07	24	<.01										T_b
Winter	3.61	24	<.01										T_s
	7.05	24	<.01										T_a
Autumn:	5.96	30	<.01										T_b
Winter	2.58	30	<.02										T_s
	5.94	30	<.01										T_a

No *Uta* was found active during this study at a T_s higher than 47.4 C or a T_a higher than 39.6 C, although temperatures in excess of T_s 50.0 C and T_a 45.0 C are commonly available. On 30 July 1967 the low T_a measured at ca. 0500 hrs. PST was in excess of 30.0 C and the high, measured at 1740 hrs., was 44.1 C. Only one *Uta* was seen that day (0625 hrs.; T_a, 35.9 C; T_s, 36.0 C).

During the hotter months of the year, the rocky hillsides are almost devoid of *Uta*, even in the early morning. It is possible that in the summer the rocks constantly maintain surface temperatures in excess of 35.0 C. Because of difficulties of obtaining accurate measurements of rock surface temperatures, this possibility was not tested. The sudden reappearance of numerous adult *Uta* in the rocky area with the advent of cooler autumn temperatures seems to suggest that a portion of the population at Saratoga Springs may estivate.

Wind speed has a negative effect on T_b ($r = -.268$, $df = 90$, $P = .01$). Gusts up to 16.0 kph do not seem to affect activity appreciably, but constant wind over 8.0-16.0 kph apparently stops or reduces activity. The species has been collected within a range of wind speeds from 0.0-12 0 kph ($X = 2.67 \pm .30$ kph).

Rain negatively affects the activity of *U. stansburiana*. Light, intermittent rain will briefly curtail activity, but as soon as the sun reappears, activity resumes. Constant light, heavy, or cold rain will stop all activity. Cloud cover can also reduce or stop activity, especially if a distinct lowering of temperature ensues.

Seasonal thermal responses, especially during winter, differ sufficiently to warrant discussion. During spring and autumn, unless it rains, *Uta* are probably active every day. During summer they are active at least part of every day, unless habitat temperatures exceed 30.0-40.0 C for the entire day. In winter *Uta* appear to be active on any day that has an ambient temperature greater than 20.0 C, and is sufficiently clear to allow them to bask. Pearson (1954) has demonstrated that a lizard, *Liolaemus multiformis*, living at high elevations in Peru can achieve a T_b high enough for activity even when ambient temperature is near freezing, if sufficient insolation is available. Cunningham (1966) reported finding *Uta* basking at T_b 14.5 C and T_s 15.0 C. Cowles (1941) reported finding *Uta* active during February 1937, " . . . an exceptionally cold winter." Tinkle (1967) reported *Uta* active on any warm day throughout the year. Brattstrom (1965) reported T_b's of *Uta* collected from February to September, and found no significant differences between them.

In January 1968 a field experiment was performed to determine the minimum temperature at which *Uta* could survive and show coordinated locomotor activity. Six animals were placed in a one gallon glass jar and left overnight. The lizards were examined early the following morning and T_a inside the bottle measured. All of the lizards were alive and T_b was measured for three of them. T_a in the bottle was 4.2 C and the T_b's were 8.2, 4.2, and 4.2 C. The lizard with the high T_b was handled slightly longer than the others. The

lizards were returned to the bottle, left for 0.5 hrs., and measured again. The bottle was then placed in the sunlight and left for an additional 20 min. T_a inside the bottle, T_b of three lizards, and observations on locomotor activity were recorded at each interval.

At T_b 4.2 C the lizards were able to move stiffly when prodded and tended to arch their tails when handled. The tails remained rigidly arched over the lizards' backs when they were put down. At T_b 7.0-8.4 C (T_a= 6.4 C) slow, coordinated movements occurred and the lizards attempted to escape when handled. When the bottle was placed in the sun, temperatures rose rapidly and most of the lizards attempted to bask by orienting maximum surface area toward the sun. At the last measurement the T_a was 10.6 C and three T_b's were 20.6, 18.6, and 16.6 C. The lizards at T_b 20.6 and 18.6 C were very active and apparently capable of normal locomotor activity. The lizard at 16.6 C was slightly more sluggish. These temperatures agree with the voluntary minimum T_b's listed by Cunningham (1966), who found *Uta* basking at T_b 9.5-19.2 C. Tinkle (1967) recorded seeing *Uta* active in winter at T_a 4.0 C, but more often at T_a greater than 10.0 C. It appears that emergence temperature of *Uta* may be as low as T_b 7.0 C and T_a ca. 7.0 C since lizards are capable of coordinated movement at those temperatures, and have been observed basking at T_b 9.5 C (Cunningham, 1966).

MBT's of *U. stansburiana* collected in spring (Feb.-April), summer (May-July), and autumn (Aug.-Oct.) do not differ significantly (Table 3), but there appears to be a tendency toward an increase from spring to autumn (Fig. 1). T_b, T_s, and T_a for winter (January) animals are significantly lower than for any other season (Table 3), a situation also observed by Roberts (1968). The difference in environmental temperatures is to be expected, with low temperatures generally being the only ones available in the environment in winter. The reduction in T_b would not necessarily be expected (Dawson and Bartholomew, 1956).

Diel thermal lability varies seasonally in *Uta* at Saratoga Springs. The correlation of T_b with time of day is very weak in spring, approaches significance in summer ($r = .501$, $df = 10$, $P > .05$), and is strong in autumn ($r = .589$, $df = 16$, $P < .05$) with T_b tending to be higher in the afternoon than in the morning (Fig. 3). T_b does not correlate with time of day in winter-collected lizards.

Callisaurus draconoides:

Callisaurus draconoides also respond primarily to temperature and have been collected over a wide range of temperatures (Table 2). T_b of *Callisaurus* correlates slightly higher with T_s than T_a (T_a, $r = .716$, $df = 78$, $P < .01$; T_s, $r = .794$, $df = 78$, $P < .01$). Soulé (1963) found a lower, but significant correlation between T_b and T_a in *Callisourus* studied by him. *Callisaurus* are found active at Saratoga Springs when every other species studied has sought shelter from the heat. Norris (1967) discusses the mechanisms enabling *Callisaurus* to maintain activity at high temperatures. Apparently 20.0 C is the lowest T_a or T_s that will be voluntarily tolerated by

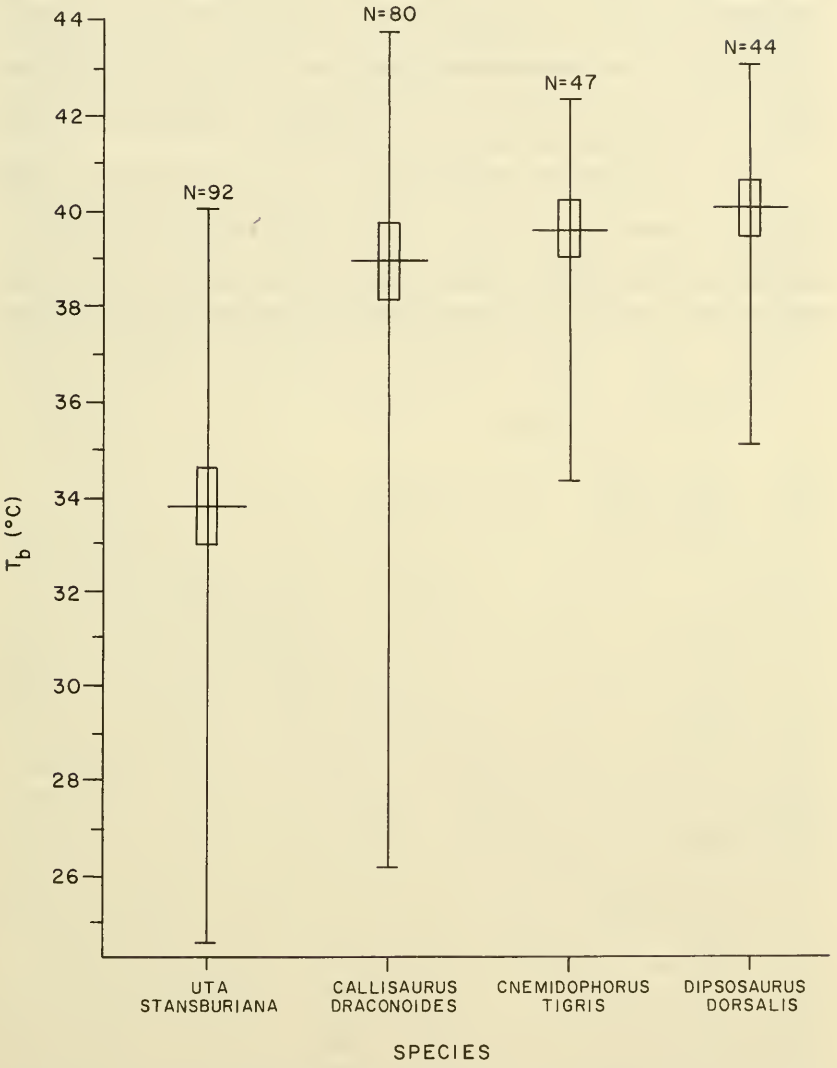

Fig. 2. A comparison of MBT of four species of active lizards from Saratoga Springs, D.V.N.M., California. Vertical line is range; Vertical bar is $2S_{\bar{x}}$.

Callisaurus. I have only three records of *C. draconoides* active at T_a less than 30.0 C and two records of T_s less than 30.0 C These records probably represent lizards that had just emerged since they are generally from early in the day and are scattered throughout the activity season (Table 2). Brattstrom (1965) lists 26.4-31.5 C as the T_b of emerging *Callisaurus* and Soulé (1963) lists 22.0 C as the

minimum T_a. The voluntary minimum T_b determined in a laboratory gradient is 29.8 C (R. Clark and W. G. Bradley, unpubl. data). The MBT of *Callisaurus* (Table 2) from this study does not appear to differ from that reported by Brattstrom (1965) or Cunningham (1966). The ranges of T_b observed are similar to those author's, except that my maxima are 3.6 C higher than Brattstrom's (1965) and 1.4 C higher than Cunningham's (1966).

I found no significant difference in T_b between the sexes (Table 3). T_{BBT} associated with active *Callisaurus* does not appear to differ significantly from T_s (T_{BBT}, $\overline{X}$= 42.15± .93 C; range, 34.0-50.8 C).

Other environmental factors that influence the activity of *C. draconoides* (wind, rain, cloud cover) are similar to those for *Uta stansburiana*. Smith (1946) noted that *Callisaurus* bury themselves just under the surface of the sand during light rains. My observa-

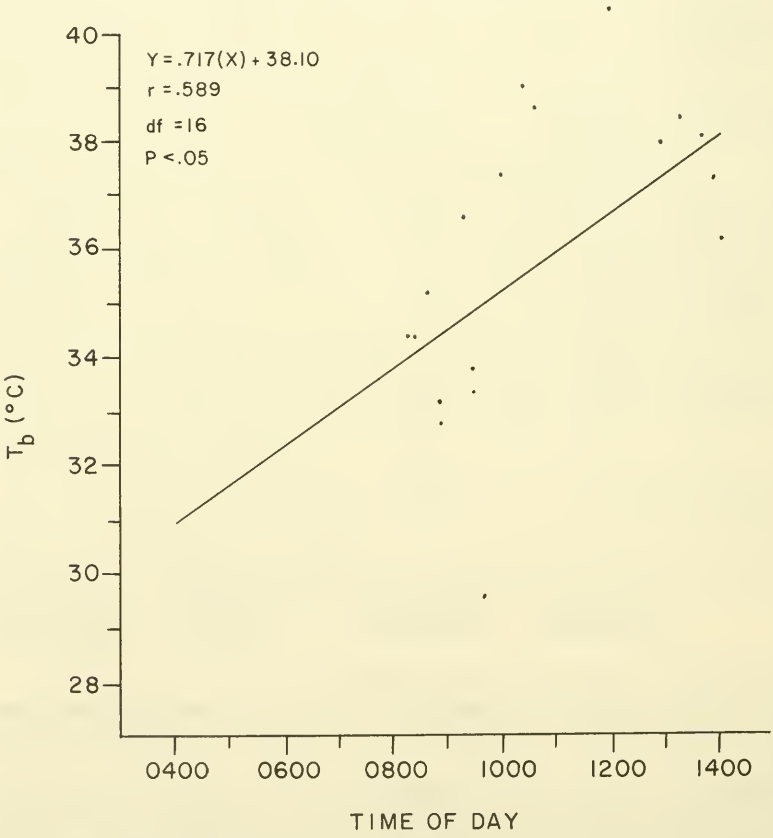

Fig. 3. Scatter diagram of T_b on time of day for *Uta stansburiana* in autumn at Saratoga Springs, D.V.N.M., California. Line fit by method of least squares. Regression equation, correlation coefficient (r), degrees of freedom (df), and significance level (P) are indicated.

tions tend to support this inasmuch as *Callisaurus* reappear very shortly after rain ceases. Moderate to heavy cloud cover can reduce activity and, if associated with a large temperature drop, stop it altogether. Zebra-tailed lizards have been collected at wind speeds up to 11.2 kph, and gusts up to 19.2 kph seem to have little effect on activity. Steady wind in excess of 8.0 kph, however, reduces or stops activity. Wind seems to have a negative effect on T_b ($r = -.117$). The mean wind speed at which *Callisaurus* has been collected is $3.09 \pm .35$ kph (range, 0.0-11.2 kph).

The MBT of *Callisaurus* does not differ significantly between the seasons (Table 3). T_b's of autumn *Callisaurus* are only slightly lower than those of spring and summer (Table 2). Diel thermal lability has been observed only in summer-collected lizards. The correlation between T_b and time of day for summer-collected animals is highly significant ($r = .660$, $df = 19$, $P < .01$). There is a strong trend toward an increase in T_b in the afternoon (Fig. 4). *Callisaurus* has not been observed during winter at Saratoga Springs.

Cnemidophorus tigris:

Several previous authors including Cowles (1940, 1941). Milstead (1957a, b), Miller and Stebbins (1964), Bostic (1966, 1968), Medica (1967), and Echternacht (1967) have studied the environmental responses and thermal relations of *C. tigris* and other species of the genus. *Cnemidophorus tigris* are most active at moderate temperatures. Table 2 shows the range and MBT for the *Cnemidophorus* collected during this study. The MBT is lower than that listed by Brattstrom (1965). There is no significant difference in MBT of male and female whiptails (Table 3). The lowest T_s at which C. *tigris* was collected in this study (25.0 C) is 3.0 C and 5.0 C lower than those reported by Milstead (1957a) and Echternacht (1967) respectively. The highest T_s recorded in this study (50.0 C) corresponds to the data of Milstead (1957a), but is higher than that reported by Echternacht (1967). Milstead (1957a) and Medica (1967) indicate that *Cnemidophorus* activity ceases when T_s reaches 50.0 C in the areas studied by them and that activity can be modified by changes in daily weather that modify temperature. My observations indicate that the same is true at Saratoga Springs.

T_b correlates higher with T_s than T_a when my data are lumped, but both correlations are significant (T_s, $r = .506$, $df = 45$, $P < .01$; T_a, $r = .422$, $df = 45$, P ($< .01$). These data agree with those of Milstead (1957a), Medica (1967), and Echternacht (1967). Milstead's (1957a) data apparently did not show such a high correlation between T_b and T_a however. The mean T_{BBT} at which *C. tigris* has been collected is 44.50 ± 2.74 C (range, 36.0-51.8 C). The mean is based on a small sample ($n = 6$), but seems to agree with the data of Milstead (1957a) and Degenhardt (1966).

There is no indication of a negative relation between wind speed and T_b for *C. tigris* collected at Saratoga Springs ($r = .027$). This may be a reflection of the species' propensity for rather dense vegetative cover. *Cnemidophorus* have been collected over a range of

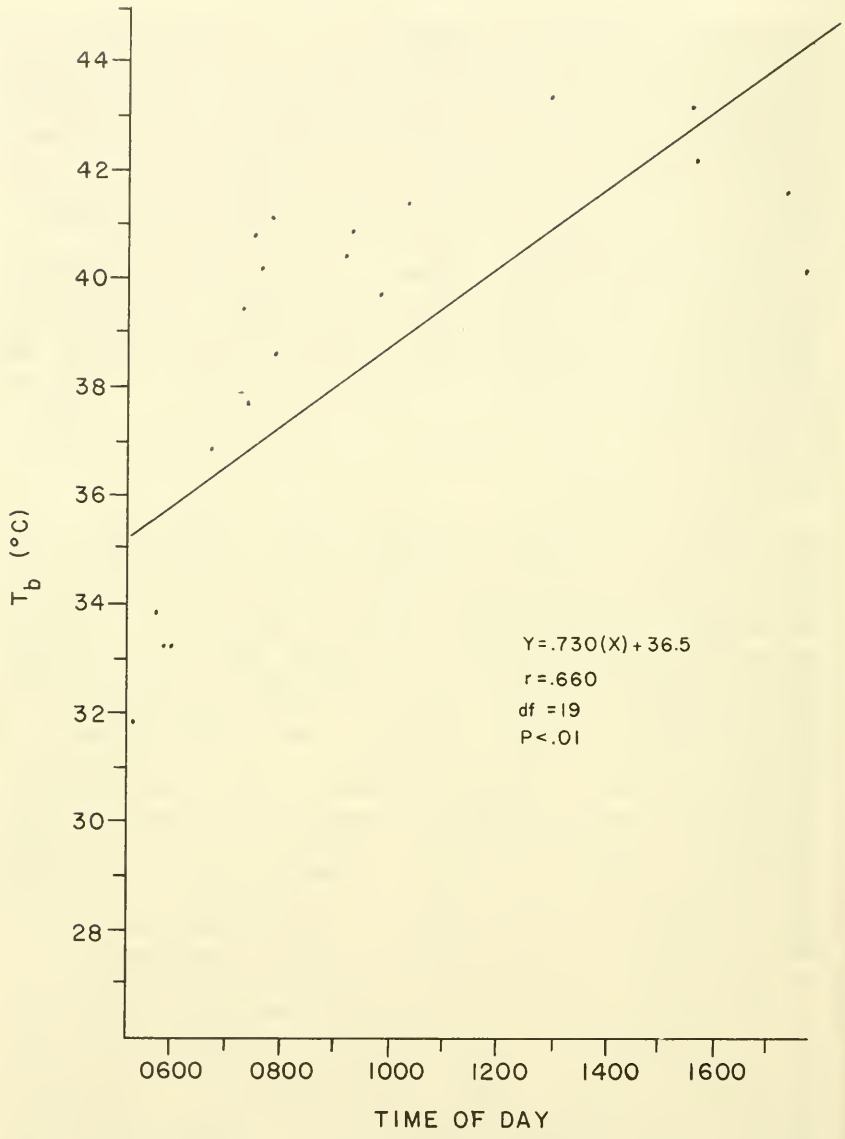

Fig. 4. Scatter diagram of T_b on time of day for *Callisaurus draconoides* in summer at Saratoga Springs, D.V.N.M., California. Line fit by method of least squares. Regression equation, correlation coefficient (r), degrees of freedom (df), and significance level (P) are indicated.

wind speed of 0.0-12.8 kph ($X = 2.90 \pm .51$ kph). Apparently wind speeds in excess of 12.8 kph cause *C. tigris* at Saratoga Springs to retreat underground or to dense cover. Echternacht (1967) reported that wind had no effect on *C. tigris* studied by him.

I have no data on the effect of cloud cover or rain on *Cnemidophorus* activity. Bostic (1966, 1968) and Echternacht (1967) report that heavy cloud cover or rain has a direct and deleterious effect on activity of *Cnemidophorus* studied by them.

There is a seasonal difference in MBT of active whiptails. MBT in spring is significantly higher than in summer (Table 3). Since autumn data are available for only one lizard, no comparison can be made with that season. No previous author has reported seasonal differences in MBT of active *Cnemidophorus*.

The correlation of T_b to environmental temperatures differs between spring and summer-collected *C. tigris* at Saratoga Springs. T_b of summer-collected whiptails correlates higher with T_a than T_s, though both are significant (T_a, $r = .734$, $df = 14$, $P < .01$; T_s, $r = .499$, $df = 14$, $P = .05$). Spring-collected lizards have a higher T_b:T_s correlation (T_s, $r = .485$, $df = 28$, $P < .01$; T_a, $r = .386$, $df = 28$, $P < .05$). I believe these correlations reflect the observation that whiptails are seen in open habitat more frequently during spring than during summer. No previous author seems to have observed a similar seasonal shift in correlation of T_b with environmental temperatures.

Diel thermal lability is found in *C. tigris* in spring and summer. T_b correlates significantly with time of day during both seasons (spring, $r = .369$, $df = 28$, $P < .05$; summer, $r = .534$, $df = 14$, $P < .05$). Although the trend toward an afternoon increase in T_b is evident, it is not as strongly marked as in *Callisaurus* or *Uta* (Fig. 5).

Dipsosaurus dorsalis:

Dipsosaurus dorsalis, as noted by Norris (1953) and Brattstrom (1965), has the highest MBT of any North American lizard yet studied. The MBT and activity range of *Dipsosaurus* from Saratoga Springs are shown in Table 2. The activity range of T_b for *D. dorsalis* measured in this study is rather narrow and the values obtained for MBT and activity range agree with those of previous authors (Norris, 1953; Brattstrom, 1965; Cunningham, 1966). The MBT of *D. dorsalis* is significantly higher than *U. stansburiana* and *C. draconoides*, but not *C. tigris* (Table 3). The T_a and T_s at which *Dipsosaurus* are active is also high, due largely to time of activity. T_a and T_s are significantly higher than those associated with *Uta* and *Cnemidophorus*, but not *Callisaurus* (Table 3). T_b of *D. dorsalis* in this study correlates more highly with T_a than T_s (T_a, $r = .574$, $df = 42$, $P < .01$; T_s, $r = .305$, $df = 42$, $P = .05$).

Wind speed has a nonsignificant, but apparently negative effect on T_b ($r = -.272$). *Dipsosaurus dorsalis* seems to be more sensitive to wind than any other lizard studied at Saratoga Springs since it was never seen or collected at wind speeds in excess of 8.0 kph. The mean wind speed at which *D. dorsalis* has been collected is $2.61 \pm$

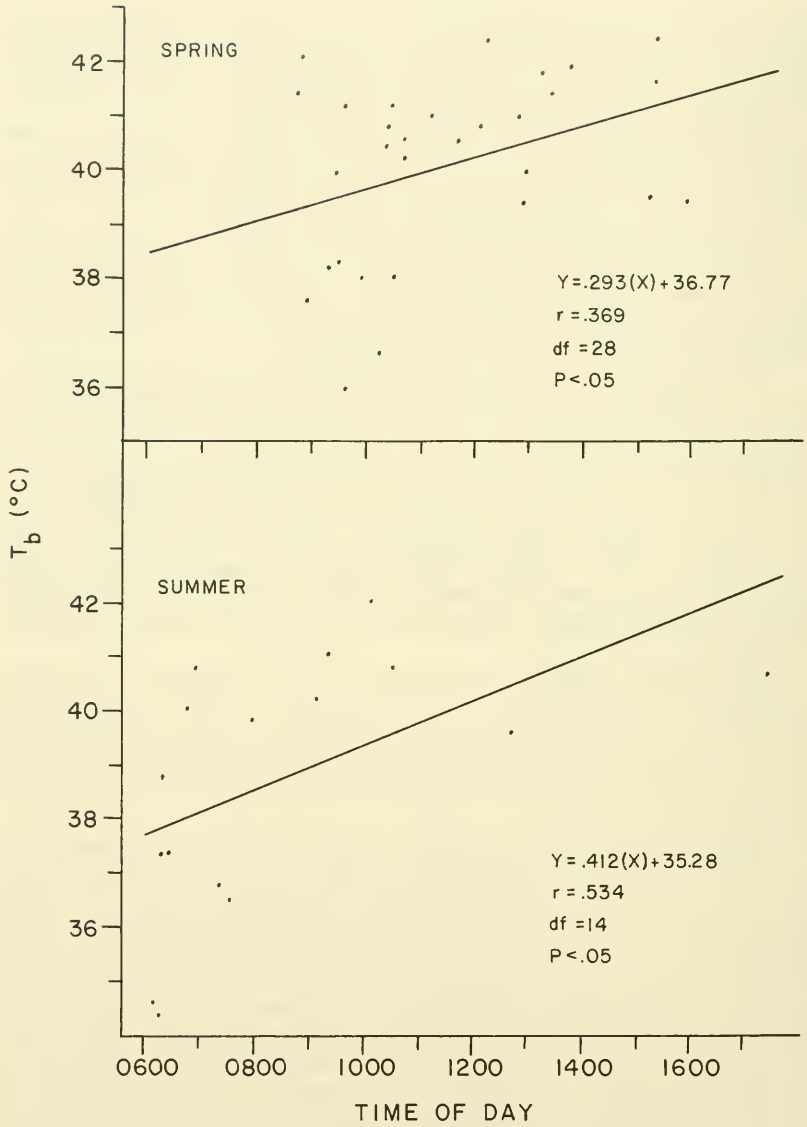

Fig. 5. Scatter diagrams of T_b on time of day for *Cnemidophorus tigris* in spring and summer at Saratoga Springs, D.V.N.M., California. Lines fit by method of least squares. Regression equation, correlation coefficient (r), degrees of freedom (df), and significance level (P) are indicated.

.66 kph (range, 0.0-8.0 kph). No data are available on the effect of rain or cloud cover on the activity of *D. dorsalis* at Saratoga Springs.

Examined seasonally, MBT of *Dipsosaurus* is significantly higher in summer than in spring (Table 3). I have no data on thermal responses of autumn lizards. There is no apparent diel thermal lability in *D. dorsalis* during any season.

Discussion

Although my results, in many respects, resemble those of previous studies, several new relationships are reported. This study permits comparisons of the thermal niches of these four species in a situation in which each species has an equal opportunity to respond to the components examined. It seems, therefore, that any differences noted between the species should be a reflection of ecological separation within the components examined.

The lizards of Saratoga Springs all respond primarily to temperature. However, each species responds differently to the available thermal mosaic. Several measures of this differential response are available. Among them are comparison of MBT's of the species, relationships between activity and environmental temperatures, and diel or seasonal lability of T_b.

Examination of Figure 2 and column 1 of Table 2 reveals that the MBT differs between the species listed although some overlap of means occurs between three of the species. The MBT of *U. stansburiana* differs significantly from all of the other species. The low MBT of *Uta* reflects the species' utilization of the lower end of the thermal spectrum. The MBT of *Callisaurus* is significantly lower than that of *D. dorsalis*, but not of *C. tigris*. The MBT of *D. dorsalis* is significantly higher than any species except *C. tigris*. T_a and T_s associated with the species also differ (Table 3).

Cowles and Bogert (1944) and Degenhardt (1966) consider black-bulb temperature to describe the limits for lizard activity. T_{BBT} is measured in direct sunlight and represents the maximum temperature available at a particular time (Cowles and Bogert, 1944). It seems reasonable to conclude that a range of T_a of 18.0-40.0 C describes the thermal limits of activity for *Uta*. The corresponding range of T_{BBT} is 25.0-48.0 C. Since during the major part of the activity day T_a seems to be the temperature that has the greatest relationship to T_b of *Uta*, I feel that T_{BBT} is a measure of potential activity only during periods when the lizards are actively basking to raise T_b (early morning, late afternoon).

Degenhardt (1966) has shown that T_{BBT} is a very reliable indicator of activity in *Cnemidophorus* and *Holbrookia* studied by him. My values for *Cnemidophorus* correspond well with his. I feel that T_{BBT} is also a valid indicator of *Callisaurus* activity at Saratoga Springs. No data are available for *D. dorsalis*.

Ruibal (1961) and Licht (1968) have shown that several species

of *Anolis* have different thermal responses associated with daily photoperiod. These authors have shown changes in T_b, preferred T_b, and heat resistance correlated with photoperiod, both in the laboratory and in the field. Hutchison and Kosh (1965) and Kosh and Hutchison (1968) have demonstrated changes in resistance to high temperature in the turtle, *Chrysemys picta*, that are related to changes in photoperiod. Three species of lizards (*U. stansburiana*, *C. draconoides*, and *C. tigris*) studied at Saratoga Springs have diel shifts in T_b (Figs. 3, 4, 5).

In autumn, *U. stansburiana* has a marked increase in T_b in the afternoon (Fig. 3). This may reflect acclimatization to high daily temperatures in summer with residual effects being shown in autumn. Roberts (1968) found a slight elevation in MBT of summer-collected lizards, but found no change in O_2 consumption in lizards from spring through autumn, except in juvenals taken during June and July. *Callisaurus*, in summer, have an increased T_b in the afternoon (Fig. 4). This is probably a reflection of the propensity of the species for activity when ambient temperature and direct insolation are at their highest. Thermal lability in *C. draconoides* may be advantageous, as mentioned by Norris (1967), by allowing the species to be active when predators and competitors are in hiding. *Cnemidophorus* shows apparent diel thermal lability in spring and summer (Fig. 5). Apparently because summer temperatures are higher than those in spring, the elevation of T_b in summer is slightly greater than in the spring. Diel thermal lability in *C. tigris*, as in the other species discussed, seems to be an adaptation allowing slightly longer activity periods under sub-optimal conditions of temperature.

A number of authors, including Lowe and Vance (1955), Wilholt and Anderson (1960), Larson (1961), Mayhew (1963), and McGinnis (1960) have described seasonal changes in T_b of field-active lizards and changes in thermal tolerance after acclimation to both high and low temperatures in several species of lizards. Three species of lizards studied at Saratoga Springs (*U. stansburiana*, *C. tigris*, and *D. dorsalis*) have significant seasonal shifts in MBT (Tables 2 and 3).

Dipsosaurus dorsalis shows a shift which may represent acclimatization to increased temperature (Table 2, 3). *Cnemidophorus tigris* has a seasonal shift in MBT that is the reverse of that seen in *D. dorsalis* (Table 2). The increased MBT of spring-collected whiptails may reflect sampling error, or may be a reflection of higher thermal requirements or increased exposure during the reproductive season.

Examination of Figure 1 reveals a gradual rise in MBT of *Uta* from spring to autumn. Although not significant (Table 3), the rise in MBT seems to support a hypothesis of seasonal acclimatization to rising temperatures. Data available on seasonal metabolism (Roberts, 1968), however, fails to show acclimatization in spring, summer, or autumn lizards.

In winter, the side-blotched lizard's MBT is significantly lower than any other season (Fig. 1, Table 3). My data are insufficient to indicate whether the observed lowering of MBT represents a shift in preferred temperature of *Uta*, or whether the winter MBT is simply the lower end of the normal range of the species. McGinnis (1966) and Mayhew (1963) reported similar changes in T_b in two species of *Sceloporus*. McGinnis (1966) demonstrated that winter-active *Sceloporus occidentalis* had the same mean preferred temperature (MPT) as summer-active lizards when tested in a laboratory thermal gradient. Regal (1967) described voluntary hypothermia in a number of reptiles tested in a laboratory gradient, but did not test *U. stansburiana*. Roberts (1968) examined T_b and O_2 consumption in *Uta* throughout the year. She observed that MBT of winter-active lizards was reduced, and that they seemed to prefer the lower range of available temperatures in the field. Her winter-collected lizards showed an increase in O_2 consumption which suggested either acclimatization to low temperature or residual effects from summer juvenals. Dawson and Bartholomew (1956), on the other hand, were unable to demonstrate temperature acclimation in *U. stansburiana* in the laboratory. I feel that the available data strongly suggest acclimatization of *Uta stansburiana* to gradual seasonal changes in environmental temperatures.

In addition to their differential responses to thermal factors, the lizards studied at Saratoga Springs also respond differentially to other environmental factors, although not in so clear-cut a manner. All of the species examined seem to respond negatively to rain. The differences noted are generally in intensity of response, rather than type. Cloud cover that reduces insolation, hence environmental temperature, appears to affect the smaller species (*Uta*) before the larger. Wind, on the other hand, produces a negative response in *Dipsosaurus* before *Uta*. This probably results from *Uta* being able to utilize small, wind-free portions of the environment that are not available to *Dipsosaurus* because of its larger size. *Cnemidophorus* at Saratoga Springs apparently shift to more sheltered areas in response to wind before ceasing activity. *Callisaurus* seem to withstand more wind than any other species before reducing activity.

This study indicates, then, that the lizard species studied are segregated within the environmental components examined. The pattern of differential responses is complex and apparently has produced maximal environmental utilization with minimal interspecific interaction. The thermal partitioning just discussed is the most obviously differentiated environmental component studied. Other data on spatial and temporal relationships of these species at Saratoga Springs (Kay, m. s.) indicate that the species most similar in thermal requirements are quite clearly segregated in one or both of the others.

ACKNOWLEDGEMENTS

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SPECIATION IN THE FIJIAN AND TONGAN IGUANA *BRACHYLOPHUS* (SAURIA, IGUANIDAE) WITH THE DESCRIPTION OF A NEW SPECIES

David F. Avery[1] and Wilmer W. Tanner[2]

The monotypic genus *Brachylophus* is one of the most geographically isolated Iguanidae known. Because its range is restricted to the Pacific Island groups of Fiji and Tonga, the genus has been neglected and specimens in museum collections and zoos are uncommon.

The genus was originally described by Brongniart in 1780 as *Iguana fasciata.* As pointed out by Savage (1952) the name *Brachylophus* first appears in the literature in Cuvier's "Le Règne Animal" (1829). Since then the generic name has mistakenly been credited to Guérin-Méneville (1829) and Wagler (1830). The species has also been described by Daudin (1803) who considered it to be an agamid and by Dumeril and Bibron (1837) who correctly placed it in the family Iguanidae.

The type locality of *Brachylophus fasciatus* is in doubt. The original description of Brongniart lists the specimens as coming from "The Indies" and having been collected in the Fiji Islands as it was not until 1899 that Waite published a range extension for the genus to the Tongan Islands. Unknown to Waite, Dumeril and Bibron (1837) indicated that they had utilized specimens from Tongatabu in their re-description of the species.

It is also our opinion that the type locality lies somewhere in the Fiji Islands. An examination of Brongniart's plate vi, figure 1 shows a *B. fasciatus* with light spots and streaks on the neck and with a light colored head. This color pattern has been observed in Fiji Island specimens seen by us and we, therefore, believe that such a pattern is endemic to the Fiji group. Light neck streaks and light colored heads have not been observed in Tongan specimens.

In 1965 we contacted Mr. Bert Nixon, who was then teaching at Nukalofa, Tongatabu Island, and through him, secured a small series of *Brachylophus* from Tonga. The skulls of two Tongan specimens were used to augment the skeletal material available for this genus at Harvard and the American Museum.

Our original study, to be published elsewhere, includes a comparative osteological and myological study of those genera belonging to the iguanine line of the family Iguanidae. However, a comparison of the skulls from the Tongan specimens with those from Fiji demonstrated several significant differences of specific level.

A comparison with material from other collections has enabled us to redefine the species *Brachylophus fasciatus* and to name as a

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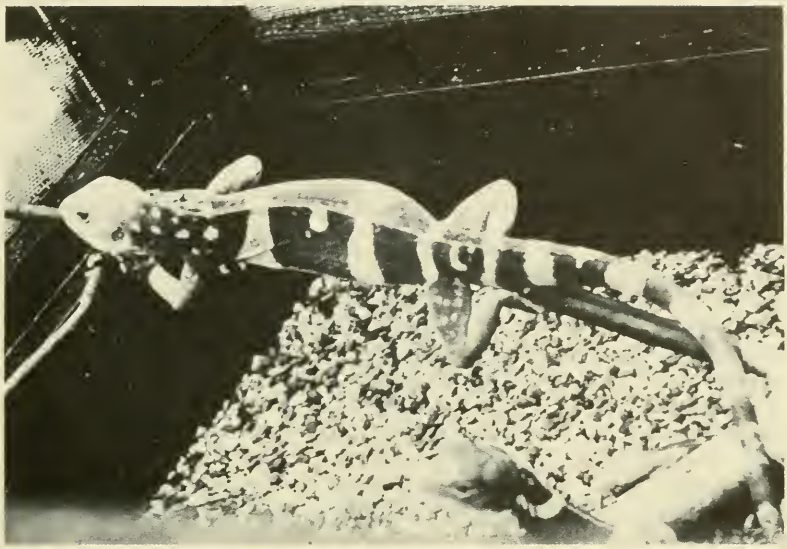

Fig. 1. A male *Brachylopsus fasciatus* from Fiji. Specimen is at the San Diego Zoo, Balboa Park. (Photo by W. W. Tanner by courtesy of Charles E. Shaw.)

new species the population of Tonga. The new species we choose to call

Brachylophus brevicephalus[3] sp. nov.
Tongan Iguana

HOLOTYPE: An adult male, BYU 32662, taken at Nukalofa, Tongatabu Island, Friendly Islands by Mr. Bert Nixon, during March, 1966.

PARATYPES: All specimens are from the collections of Brigham Young University (BYU), University of Utah (UU) and the California Academy of Science (CAS). Topotypes, BYU 32661, 32663, 31955, 23743, 31094, 31095, 31096, 31102; UU 11014 and CAS 50135, Maufanga, Tongatabu.

DIAGNOSIS: A moderately large lizard resembling an iguana in body form and distinguished from *B. fasciatus* by a higher number of dorsal scales 100.0-128.0 (average 111.0) as contrasted to 68.0-98.0 (average 84.2 in *fasciatus;* a lower number of total femoral pores 9.0-26.0 (average 21.5) as opposed to 17.0-38.0 (average 26.7) in *fasciatus;* a higher number of scale rows 183.0-205.0 (average 190.7) as opposed to 146.0-201.0 (average 177.0) in *fasciatus;* a higher number of supranasals 2.0-3.0 (average 2.2) as opposed to 1.0-2.0 (average 1.2) in *fasciatus;* skull with a greater length-width ratio .655-.735 (average .712) as opposed to .535-.657 (average .615) in *fasciatus.*

[3]The term *brevicephalus* refers to the short head characteristic of the Tongan *Brachylophus.*

Scale counts are summarized in Table 1 and skull measurements of the two species are summarized in Table 2.

Description of the Type: Total length 640 mm., snout-vent length 166 mm., dorsal scales 128, ventral scales 158, scale rows around body 191, femoral pores 12-11, infralabials 8-8, rostral scale single, supranasals 2, infranasals 3, mental split with post mental

Table 1. A comparison of the scale characters in *Brachylophus*

Character	*B. brevicephalus* N=10	*B. fasciatus* N=21
Scale Rows	183.0-190.7-205.0	146.0-177.0-201.0
Dorsals	100.0-111.0-128.0	68.0-84.2-98.0
Total Pores	9.0-21.5-26.0	17.0-26.7-38.0
Supranasals	2.0-2.2-3.0	1.0-1.2-2.0
Infranasals	3.0-4.0-5.0	4.0-4.1-5.0
Ventrals	158.0-168.6-178.0	138.0-159.0-190.0
Total Supralabials	14.0-16.5-22.0	12.0-19.0-21.0
Total Infralabials	14.0-16.7-18.0	12.0-16.2-19.0
Mentals	1.0-1.7-2.0	1.0-1.8-2.0

Table 2. Skull Characters[1] in *Brachylophus*

Character	*B. fasciatus**	*B. brevicephalus***
Skull L X W	.535-.615-.657	.655-.712-.735
Basisphenoid	.591-.592-.594	.526-.640-.655
Basioccipital	.700-.740-.781	.494-.571-.648
Supraoccipital	.852-.917-.982	.792-.838-.885
Pterygoid	.406-.484-.535	.309-.344-.380
Ectopterygoid	.333-.349-.372	.390-.415-.440
Palatine	.562-.605-.658	.500-.551-.602
Premaxilla	.442-.535-.613	.629-.650-.671
Nasal	.541-.554-.564	.422-.424-.427
Prefrontal	.535-.571-.619	.460-.517-.574
Jugal	.160-.180-.201	.190-.205-.220
Parietal Wings	.734-.759-.778	.776-.780-.785
Postorbital	.745-.757-.769	.800-.841-.883
Quadrate	.569-.605-.642	.489-.518-.537
Narial Orfice	.804-.885-.951	.725-.779-.833
Dentary	.202-.206-.210	.216-.225-.235
Articular	.240-.264-.288	.364-.382-.400
Angular Process	.130-.144-.158	.164-.174-.185
Splenial	.263-.280-.298	.328-.420-.513
Angular	.152-.181-.211	.206-.207-.208
Articular Condyle	.805-.819-.833	.833-.849-.866

[1]All skull ratios are width divided by length, length being the greatest distance along the median axis. Width is the greatest distance at right angles to the length.
*Based on the following skulls: MCZ 15009, 5222, 15008; AMNH 17701.
**Based on the following skulls: BYU 23743, 31955, 32663; UU 11014

separating chin shields, body short and stout with dorsal crest, tail long and compressed laterally at base.

Body with 4 dark, transverse bands and 3 light, transverse bands, most anterior dark body band interrupted by a single light spot directly over scapula, tail also banded.

Color in alcohol: Basic color a dark bluish green with light greenish blue bands; neck spot same color as light colored bands.

Color in life: Dark body bands very dark green, light bands turquoise or bluish green, limbs and tail bands leaf green, eye red. In *B. brevicephalus* the head is the same color as the dark body bands. In *B. fasciatus* the head and neck spots are same color as the light body bands.

Variation: The greatest variation in this species appears to be in the scale pattern under the chin. The mental is always split but chin shields may or may not be present. When present they may be separated anteriorly by a post mental or may meet at the mid ventral line and displace the post mental posteriorly. In some cases two post mentals may be present.

Besides the differences cited in the diagnosis of *B. brevicephalus* there is considerable variation in coloration and scalation of *B. fasciatus*. Scales of the chin are much less variable than in *brevicephalus* with the mental always being split and chin shields almost always touching. This results in the post mental being displaced posteriorly or being lost entirely. Scales of the head are always platelike and polygonal or hexagonal in shape.

Color differences are apparent in the two species. *B. fasciatus* males have spots and/or streaks on the necks and light colored heads. In some forms the necks are of a solid color. The banding of the body and tail appear to be about the same as in *B. brevicephalus*. Body bands are absent in females of both species. Females of *brevicephalus* have small light spots sparcely scattered over the body.

Sexual dimorphism is evident in the Fiji populations, with females having less well developed dorsal crests and more femoral pores than males. Females also lack the light body bands so prominent in males. For a summary of scale characters in males and females of *fasciatus* and *brevicephalus* see Table 3.

The two species also vary in the size and arrangement of some head scales. In *brevicephalus* the two postrostral scales touch at top of rostral, whereas these scales do not touch in some *fasciatus*. Head scales of *brevicephalus* are smaller and more granular than those of *fasciatus*. In the latter they are large and have a regular polygonal to hexagonal shape.

Remarks: We consider the new species to be more primitive than *fasciatus*, by virtue of its having less specialized head scales, more dorsals, more scale rows and in general a series of scale patterns which are seemingly more primitive. Its range is also to the east of *fasciatus* and if one assumes a South or Central American origin for the group, it would probably represent the earliest population to raft to the Southern Pacific area. The Fiji populations were probably derived from this ancestral stock.

Table 3. Scalation of males and females of *B. fasciatus* and *B. brevicephalus*

Character	*B. fasciatus* Females N=9	Males N=12
Scale Rows	161.0-184.4-201.0	146.0-163.8-.97-0
Dorsals	28.0-88.2-98.0	68.0-83.7-100.0
Ventrals	146.0-167.0-174.0	138.5-161.6-190.0
Total Pores	23.0-27.6-38.0	17.0-26.1-33.0
Total Supralabials	13.0-17.0-21.0	12.0-15.7-19.0
Total Infralabials	13.0-16.5-18.0	12.0-16.0-19.0
Supranasals	1.0-1.1-2.0	1.0-1.3-2.0
Infranasals	4.0-4.2-5.0	3.0-4.0-5.0
Mentals	1.0-1.8-2.0	1.0-1.9-2.0
	B. brevicephalus	
	Females N=2	Males N=8
Scale Rows	183.0-190.0-197.0	184.0-191.0-205.0
Dorsals	100.0-103.5-107.0	100.0-114.0-128.0
Ventrals	160.0-161.5-163.0	160.0-171.0-178.0
Total Pores	20.0-23.0-26.0	9.0-21.1-26.0
Total Supralabials	16.0-16.0-16.0	14.0-19.0-22.0
Total Infralabials	17.0-17.0-17.0	14.0-16.6-18.0
Supranasals	2.0-2.0-2.0	2.0-2.1-3.0
Infranasals	4.0-4.5-5.0	3.0-3.8-5.0
Mentals	2.0-2.0-2.0	1.0-1.7-2.0

Burt (1932) indicates that these island groups were populated from invasions coming from the west or that some species may have been endemic. Although this may be the case for the great majority of species now extant in these islands, we do not believe this to be true for the iguanids. In a major study to appear soon these considerations will be dealt with in more detail.

A statistical analysis of two populations was made utilizing scale counts found in Table 1. The approximate F value of the U statistic, testing the null hypothesis that two populations were the same, was 38.91414, with degrees of freedom 2, 22. $^{F}(.9999, 2, 22) = 11.4$. Therefore, the null hypothesis is rejected indicating that the two populations are different.

A canonical correlation (Program BMDO7M, Dixon 1968: 214a-214t) was utilized to form a two dimensional representation of the specimens relationships to each other for the P dimensional hyperspace (P=19). This relationship is represented in Figure 2.

Materials: Besides the specimens of *B. brevicephalus* from Tonga, a series of *B. fasciatus* was examined from the Fiji Islands. Included in this series are the following: AMNH 29009 - Vatu Vara, 29013 - Oneata, 29016 - Fiji Islands, 29034-35 - Avia, 40474 - Kandavu; CAS 54664 - Fiji Islands; MCZ 5800 - Viti, 6457-8 - Luva,

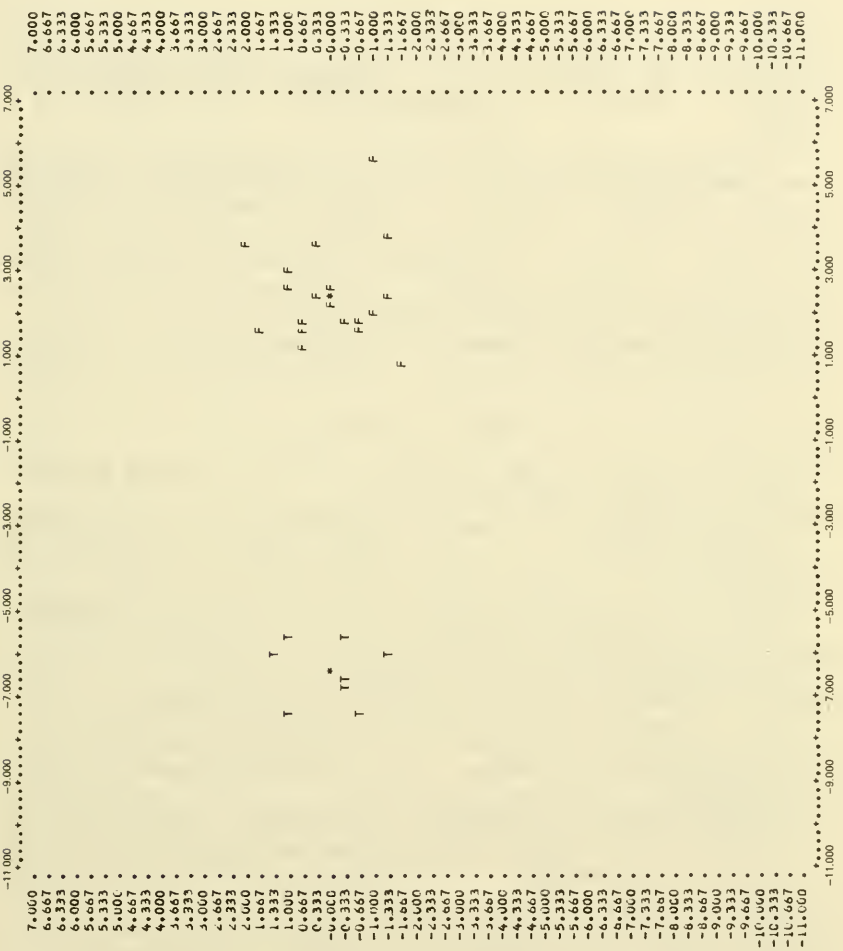

Fig. 2. The distribution of Tongan and Fijian specimens as determined by a canonical correlation. T=Tongan specimen, F=Fijian specimen, *=means of each population.

15005 - Lukeah, Lau Archipelago, 15006 - Buke, Levu Island; CNHM 60117 - Suva, Viti Levu, 140290 - Viti Levu; and USNM 51000-01 - Fiji Islands, 51410 - Viti Lerri, 58807 - Fiji Islands. Figure 2 is from a live specimen recently received from the Fiji Islands.

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STUDIES IN NEARCTIC DESERT SAND DUNE ORTHOPTERA

Part XII. A Remarkable New Genus and Species of Stenopelmatine Crickets from the Viscaino Desert, Baja California, Mexico, with Key.

Ernest R. Tinkham[1]

During the month of June, 1968, the author in company with five other men, none of whom were scientists, made a fast and very rough trip to the Viscaino Desert of central western Baja California, Mexico. Accompanied by Mr. Joe Ingram, owner and driver of a new jeep, we were able to penetrate, with the help of a Pima Indian guide, to San José del Castro, an adobe hut, some 39 miles SE of San Bartolome Bay.

The purpose of the trip was various, but for the author chiefly scientific. These aims were to reexamine the flora and fauna of the Cirio and Viscaino and Colorado Deserts; to collect a new genus of sand loving grasshoppers first found by the enterprising Mr. David Werner in the summer of 1965; to collect further specimens of the rare James' Horned Lizard for distributional studies and to obtain, if possible, additional material of a remarkable Stenopelmatine Cricket found by Werner in 1965 and which is the purpose of this paper.

The trip was considered highly successful and all the aims of expedition were realized except that no additional material of this Stenopelmatine cricket was obtained. In addition the trip brought several surprises. Several new acridids were discovered as well as camel crickets, sand roaches, decticids, cicadas and scorpions as well as other insects of interest.

The writer wishes to acknowledge here the four summer National Science Foundation grants, 1957 to 1960 inclusive, which expedited his sand dune studies commenced in 1952 and initiated these studies which have produced eleven published parts to date.

Key to the Genera and Species of the Stenopelmatine Crickets of the Californias

1. Caudal tarsi straight, normal in form. Caudal calcars of the caudal tibiae rather long, 6 in number and of irregular length, the one at the dorso-internal base the longest; that at the dorso-external base the shortest. Caudal tibial teeth absent or vestigial to well developed. Body form normal, size small to large 2

   Caudal tarsi greatly modified for arenicolous habitus, the basal segment greatly flattened, planate, rotated laterally

[1]Indio, California.

so that the 3 remaining segments are semicircularly twisted to the side, the ungues elongate with internal and external margins fringed with row of long hairs to aid in sand-surface propulsion. Caudal calcars, much shortened, broadly spathulate for sand excavation; caudal tibiae with only three very small, vestigial, external dorsal teeth. Body form normal ..... *Viscainopelmatus* n.g.

2. Tibial teeth vestigial or lacking on the apical dorsal margins of the caudal tibiae. Ringlet of apical calcars of caudal tibiae subequal in length, broadly spathulate on inner surface for arenicolous habitus. Median or presubapical spur on the ventral surface of the foretibiae absent. Pronotum not expanding anteriorly. Coloration uniformly orange. Size medium to medium large. Kelso Dunes ..... *Ammopelmatus kelsoensis* Tinkham

Tibial teeth prominently developed on the apical dorsal margins of the caudal tibiae. Ringlet of six apical calcars of hind tibiae conical or subconical in form, the innermost the longest. Median or presubapical spur on the ventral surface of the foretibiae present (except in *nigrocapitatus*). Pronotum expanding anterioradly and concealing the posterior portions of the large head. Size small to large. Coloration variable. Widely distributed in the western United States and Mexico ..... *Stenopelmatus* Burmeister 3

3. Foretibia bearing only two ventral apical spurs posterioradly to calcars III and IV 4

Foretibia bearing 3 ventral apical and subapical spurs, the first two somewhat paired and proximal to the third and fourth calcars, the third subapical to this pair. Size small to very large. Coloration variable 5

4. Caudal tibiae with three dorsal apical and subapical teeth on each margin. Caudal tibiae with a pair of ventral apical spurs. Size large, coloration orangish ..... *coahuilensis* Tinkham

Caudal tibiae with 3 dorsal apical and subapical teeth on each margin. Hind tibiae with usually one (sometimes a minute second) ventral apical spur immediately anterior to calcars III and IV. Occiput capped with black cap in adults and subadults ..... *nigrocapitatus* Tinkham and Rentz

5. Adult size very large (35-50mms long). Color of head and pronotum orange red. Head often megacephalous 6
Adult size medium to small (less than 35 mms in body length). Color of head and pronotum not orange red but piceus or shining black, the black isolated into irregular areas by pale suture lines 7

6. Calcars of the hind tibiae forming a semi-ringlet of six long spurs, innermost two longest, cylindrical and acuminate in form ..... *longespina* Brunner

   Calcars of the hind tibiae forming a semi-ringlet of 6 spurs, these spathulate or trowel-shaped on their inner faces, the inner three relatively equal, but longer than the outer three ..... *fuscus* Haldeman

7. Entire head and body uniformly dark brown with black abdominal tergites. Caudal tibiae with four to five internal and two to three external apical and subapical dorsal teeth ..... *intermedium* Davis & Smith

   Upper part of head shining black with tan sutural areas. Pronotum dorsally with irregular areas of shining black. Outer face of all femora with irregular pale brown patches of infuscation. Caudal tibiae with three to four internal and two external apical and subapical dorsal teeth .... *pictus* Scudder

Viscainopelmatus Tinkham n.g.

Generic Diagnosis: This new genus is remarkably characterized by the strange and unique form of the caudal tarsi, showing an adaptation so unusual to arenicolous environment that were the entire eremicolous world searched over, it is doubtful whether another such case exists. This remarkable modification is shown by the caudal tarsi which seldom exhibits much change except perhaps in Schizodactylinae where lateral tarsal pads are present. In the new genus the caudal tarsi are semicircularly twisted laterally; the first basal segment is greatly expanded and planate and the ungues are ampliate or swollen in basal five-sixths so that only the apices are uncinate and chitinous, the median internal and external sides lined with several rows of long hairs, the whole of which assists greatly in propulsion of a heavy bodied creature over fine sands.

Form normal and size large for the subfamily. *Viscainopelmatus*, new genus, is amply distinct from *Ammopelmatus* Tinkham, 1965, and *Stenopelmatus* Burmeister, 1832, by the strange modifications of the caudal tarsi; it is further distinguished from these genera by lacking the strong, dorsal, internal and external apical teeth of the caudal tibiae and in addition there are only three vestigial, subapical dorsal teeth on the external margin of the caudal tibiae. The pronotum in the new genus more closely approximates that in *Stenapelmatus* than *Ammopelmatus* since it is very slightly broader anterioradly. Naturally closest relationships appear to be to *Ammopelmatus* because both genera are strictly arenicolous in habitus.

In addition to above salient features, *Viscainopelmatus* n.g. like *Ammopelmatus* has shorter and stouter legs for sand propulsion and digging, with all femora and tibiae quite arcuately or convexly bowed on their forward or dorsal margins.

Genotype: *Viscainopelmatus davewerneri* n.g. et n.sp.

Viscainopelmatus is named after the Viscaino Desert of west-central Baja California and the great Viscaino Peninsula. This desert is named after Sebastian Viscaino, the great Spanish explorer of the seventeenth century. This desert is characterized by low sandy reaches, with dune areas rare inland but fairly common coastally; with night and morning fogs dissipating by noon and with a great variety of plants, many of which are endemic to this desert.

Extensive coastal and inland areas, such as surrounding the south end of Scammon's Lagoon are dominated by *Frankenia Palmeri* and drier areas often show a great admixture of plants such as Peninsular Ocotillo (*F. peninsularis*), Agaves, cacti, both giant and small, Jatrophas and many other trees and shrubs. A breathtaking sight in June is to see the Copalquin (*Pachycormus discolor Veatchiana* (Kell) Gentry) emblazoning an arroyo, their massive short trunks crowned with myriads of salmon rose flowers.

Although the soil is extensively sandy, dune areas are low and infrequent inland, but quite extensive coastally. The Giant Yucca, *Yucca valida*, forms extensive Yucca savannahs just inland of the coastal dunes northeast of Guerrero Negro.

Viscainopelmatus at present is known only from the coastal dunes at Laguna Manuela, some fifteen miles or so northeast of Guerrero Negro where it is extremely rare.

Viscainopelmatus davewerneri n.sp.

Holotype: 1 specimen minus abdomen which was cut off while excavating a rodent burrow. Coastal dunes at Laguna Manuela, some 15 miles northeast of Guerrero Negro, Districto Sul, Baja California, July 5, 1965, David Werner and party. Since the author's expedition failed to discover additional material of this curious creature, the writer finally decided after much thought and consultation to make known this new genus and species to the scientific world. Furthermore and fortunately both male and female crickets are usually identical in morphological features other than the sex organs which exhibit no specific characteristics.

Description: Size large, head typical of Stenopelmatine crickets; clypeal boss, when viewed in lateral profile slightly more prominent than in *Stenopelmatus* or *Ammopelmatus*. Pronotum, when viewed from above, approximating more closely *Stenopelmatus* than *Ammopelmatus* in that it is slightly ampliate forward; the posterior margin squarely truncate, the anterior margin typically emarginate with margin hirsute. In lateral profile the pronotum is typical of the subfamily. Abdomen missing, cut off by a spade while excavating the burrow that housed the cricket.

Leg Spination as Follows: Forelegs, smooth, fore femora with dorsal margin quite arcuately rounded; fore tibiae with both dorsal and ventral margins arcuate; calcars five, typical, numbers II and III much the longest and subequal, number IV next in size and

number V shorter than number I. Apical spurs on the ventral margin of the foretibiae, two in number, with the largest immediately caudad of calcar III and with a smaller spur slightly subapical and caudad of calcar IV; protarsi typical. Mesolegs with mesofemora typical; mesotibiae typical with six terminal calcars, and with a median placed small spur on the internal dorsal margin and a similar spur on the external, dorsal margin placed in a subapical position. Mesotarsi typical.

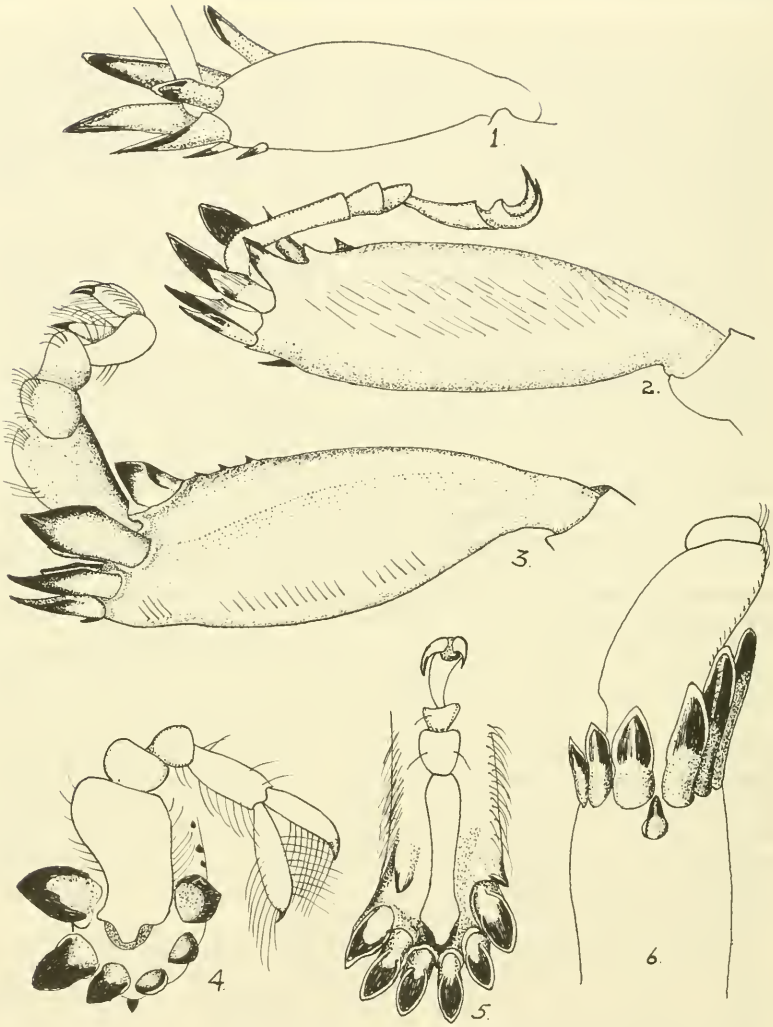
Hindlegs with caudal femora smooth, with dorsal margin strongly arched (see figure 1), ventral margin straight, with fine scattered hairs in sort of two rows externally and just below the dorsal margin, and another row supraventrally. Caudal tibia with dorsal and ventral margins arcuate, the dorsal internal margin devoid of teeth, the dorsal external margin bearing three minute black teeth in almost apical position (see figure 6); ventral margin bearing a single, short but stout, apical, black spur situated immediately basad of space between calcars III and IV so that its apex projects into space between the two calcars; this spur having great generic and specific import. Calcars six in number, greatly shortened and broadened; numbers I to III of equal size, numbers IV to VI very slightly longer with number VI the longest. Inner surface of all calcars truncate and trowel-shaped for excavation and forward propulsion across the surface of soft sand.

Caudal tarsi spectacularly modified for sand habitus, first segment twisted laterally and greatly expanded so as to form a plane surface or sole with a small tuft of short hairs apically on each margin. Second segment short and broad, ampliate forward, the inner margin arcuate and longer than the outer so that the third segment of smaller and similar shape is twisted exterioradly and circularly outward, thus forcing the fourth into a downward position (see figure 4). The ungues are unusual, too, since they appear elongated and unsclerotized so that only the extreme apex is uncinate and sclerotized. The lateral margins of ungues also bear long curving hairs which further assist in sand propulsion.

Caliper Measurements: Body length approximately 30 to 35 mms; pronotum 7.2x8.8 mms in breadth; caudal femora 10.0x4.1; caudal tibiae 10.8 3.5 mms. Type deposited in the Tinkham Eremological Collection.

Orthoptera Associates: These were several but must be studied. The sand roaches, *Pristoceuthophilus* and *Ceuthophilus* and other species are probably new.

Coastal Dunes at Laguna Manuela: These dunes are low, probably no more than 10 to 15 feet in greatest height and semi-stabilized. The shrub growth was considerable and of a height for one to become easily lost at night, especially if foggy. The main shrub was a cut-leaved, yellow flowered composite, but no special study of the dune flora has been made. Our camp was at the east edge of dunes in Yucca Savannah and was infested with a reduviid bug, called the Hualpai Tiger. Large numbers were collected at night with forceps. While endeavoring to pick up one carefully by



Explanation of Plate

1. External view of foretibiae of Holotype of *Viscainopelmatus davewerneri* Tinkham n.g. et s. sp. greatly enlarged.
2. External view of right caudal tibia and tarsus of *Ammopelmatus kelsoensis* Tinkham, greatly enlarged.
3. Internal view of caudal tibiae and tarsus of Holotype of *Viscainopelmatus davewerneri* Tinkham n.g. et n.sp., greatly enlarged.
4. Ventro-posterior view of the apical area of the right tibia and tarsus of the Holotype of *Viscainopelmatus davewerneri* Tinkham n.g. et n.sp. portraying the remarkable modifications of caudal tibia and tarsus, all greatly enlarged.
5. Ventro-posterior view of the apical area of the right caudal tibia and tarsus of *Ammopelmatus kelsoensis* Tinkham, greatly enlarged.
6. Ventral view of apical portions of left caudal tibia and tarsus of Holotype of *Viscainopelmatus davewerneri* Tinkham n.g. et n.sp. showing the diagnostic ventral apical tibial spur and the planate tarsal segment, all greatly enlarged.

hand, the writer received an excruciating puncture. Fortunately none succeeded in getting into our sleeping bags.

FAUNAL DESIGNATION: As already indicated, *Viscainopelmatus* is a most distinctive and bizarre member of the Viscaino Desert which has hardly been studied. Stanley C. Williams in the last three years has named numerous new scorpions from Baja California, some from the Viscaino Desert, showing that the fauna of Baja California peninsula has been hardly touched by zoologists.

It is a great privilege to name this remarkable new genus and species in honor of its discoverer, Mr. Dave Werner, an enterprising and persevering entomologist, an educator of note, a naturalist and bird artist of distinction, who in recent years has devoted his life as a medical missionary to bring life and hope to the impoverished folk inhabiting the beautiful barrancas of the Sierra Madre Occidentale of central Sinaloa, Mexico.

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The Great Basin NATURALIST

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GREAT BASIN NATURALIST

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The Great Basin Naturalist

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Volume XXX December 31, 1970 No. 4

VASCO M. TANNER

C. Lynn Hayward[1]

During the summer of 1925 there arrived on the campus of Brigham Young University a young man who had received his Ph.D. from Stanford University that same year. Dr. Vasco M. Tanner had come to serve as chairman of the newly organized Department of Zoology and Entomology at the University.

Prior to the coming of Dr. Tanner a diversity of courses in the biological sciences were taught under several teachers. In 1903 Brigham Young Academy became a University through the efforts of President Benjamin Cluff. One of the early teachers of biological subjects was Chester Van Buren, who had accompanied President Cluff on an expedition to Central and South America. The school at that time, being principally a high school, offered only a limited number of courses on a college level, but Mr. Van Buren taught a course in ornithology during the 1904-05 school year. Later the curriculum was expanded to include courses in plant physiology, field botany, zoological collecting, and taxidermy. In 1908-09 a Department of Biology was organized, and for a three-year period Dr. Ralph V. Chamberlain was head of the department and was assisted by Chester Van Buren, Andrew T. Rasmussen, and Charles H. Carrol. Chamberlain left the University soon afterward. Van Buren departed to go into private business, Rasmussen went away for graduate work and later became a well-known neurologist, and Carrol eventually became a medical doctor.

Beginning about 1913 Professor Edwin Smart, who was trained primarily as a horticulturist, taught a course in entomology until his untimely death in 1920. Dr. Martin P. Henderson became professor of biology in 1915. He was assisted by Professor Smart and later by Drs. Horace G. Merrill and L. Weston Oakes, who had joined the medical staff and taught courses in physiology and health. Dr. Henderson became ill in 1923 and never again returned to his duties at the University. His work was taken up by Walter P. Cottam with the assistance of Drs. Merrill, Oakes, and Dr. Charles H. Carrol who had returned after completing his M.D. degree.

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On the arrival of Vasco M. Tanner in 1925 the biological work was divided into the departments of bacteriology, botany, and zoology. These departments were housed in the old Education Building on what had become known as the lower campus. At that time only the Maeser Building and the lower floor of the Brimhall Building stood on the upper campus. The space available for the newly organized Department of Zoology and Entomology consisted of two sizable laboratories, one or two smaller laboratories, and a little office space. Equipment was limited to about thirty microscopes and other minor items. Budgets were low, and for the most part teachers and students had to find their own animal specimens for study and dissection. As a student at that time, I recall taking a course in vertebrate zoology in which about all we had to work with in the laboratory was an old dogfish which had been dissected several times previously. Library facilities were also very limited. Perhaps all of the books and journals on the biological sciences then in the University library could have been placed in one or two sections of our present library.

Dr. Tanner, with his characteristic enthusiasm and vigor, soon began to remedy the lack of material for teaching and research. A field collecting expedition was organized in early summer of 1926. Besides Dr. Tanner, the expedition personnel consisted of Clarence Cottam, Claudeous Brown, and C. Lynn Hayward. The collection of entomological specimens was the main object of the expedition, but Clarence Cottam also collected a number of birds, and a fossil fish collection was obtained in Wyoming. Some fish, amphibians, reptiles, and plants were also collected. The itinerary included the shores of Great Salt Lake, parts of Weber County, Bear Lake Valley, southwestern Wyoming, the Uinta Mountains, and the Uinta Basin.

Transportation facilities for the expedition consisted of a Model T Ford and a trailer, which, when loaded, weighed almost as much as the Ford. The trip lasted nearly six weeks and was not without its vicissitudes and even perils, but it was the beginning of a long chain of collecting trips led by Dr. Tanner and others who have followed him. Extensive and invaluable collections are now available in the University for the use of students, teachers, and researchers.

Vasco Myron Tanner was born in Payson, Utah, October 29, 1892. The family later moved to Fairview, Utah, where Vasco received his early schooling. In 1915 he graduated from Brigham Young University. In 1920 he earned a Master of Arts degree from the University of Utah where he worked mainly in geology and paleontology and wrote his thesis on the ancient Lake Bonneville. From 1916 to 1924 he was head of the Department of Biology at Dixie College. He also served as state crop pest inspector during part of this time. While he was at Dixie College, Vasco met and married Annie Atkin, and they became parents of four girls and a son—Carol, Gloria, Marilyn, Carmela, and Jordan.

In 1924 Dr. Tanner left Dixie College to continue his graduate studies at Stanford University where he was awarded a Ph.D. in 1925. His special research interests were in entomology, particularly

in the field of insect morphology. He was, however, interested in many other facets of the biological sciences and became broadly trained in other areas. At the time of his sojourn at Stanford he came under the influence of the famous David Starr Jordan who aroused his interest in fishes and had a great influence on his life in many other ways. Jordan was, in turn, a student of the renowned Louis Agassiz. The broad biological interests and training of these famous naturalists were sources of great inspiration to Vasco Tanner and prepared him well for his responsibility of building a Department of Zoology and Entomology at Brigham Young University.

Vasco M. Tanner

During the long period that Dr. Tanner served as department chairman, from the summer of 1925 to May 31, 1958, much of the emphasis in the biological sciences was in the areas of taxonomy, distribution, ecology, and morphology. Dr. Tanner had many interests and was instrumental in amassing a large collection of insects, particularly in the order Coleoptera, and in seeing that these were housed in suitable cabinets. He was also active in building collections of fishes, amphibians, and reptiles and encouraged the growth of bird and mammal collections. He was interested in fresh water biology and spent several summers studying the lakes of the Uinta Mountains and other freshwater bodies in the West. Numerous publications listed in another section of this paper reflect his research interests in many of these areas.

These collections, together with the notes and published papers of Dr. Tanner and his students and associates, become increasingly valuable as the years go on and the growing pressure of rising human populations threaten the survival of many living organisms as well as the communities in which they live.

Up to the time of Dr. Tanner's retirement as chairman of the department, approximately sixty master's theses were produced. The doctoral degree was not offered during his tenure as chairman. Of the sixty theses, about forty were written under Dr. Tanner's personal supervision. The contribution to science of one man cannot be measured solely from his own works but must include the works of those who may in one way or another have come under his stimulating influence. Dr. Tanner constantly advised his students that a piece of research is not complete until the findings are on the

printed page. This writer once undertook to assemble a bibliography of the writings of all the graduates of the Department of Zoology and Entomology from its beginning to 1960. While the list is undoubtedly incomplete, it contains about 870 titles. If it were brought up to date it would undoubtedly surpass the thousand mark.

During his professional lifetime in Utah, Dr. Tanner has been active and influential in the advancement of the biological sciences not only at Brigham Young University but at other institutions and agencies within the state. His interest in building collections of natural history objects stimulated other universities and colleges with the result that many thousands of specimens have been assembled for teaching and research. The farsighted value of this activity can be appreciated more as time goes on and as the danger of extinction of many species becomes more evident.

Another contribution of Dr. Tanner to science in Utah came about as a result of his early interest in and vigorous support of what was known at first as the Utah Academy of Science and later became the Utah Academy of Sciences, Arts, and Letters. For many years he was secretary of the academy and editor of its journal. During his editorship there was much interest in the biological and other sciences, and many important papers were published. Following his time as editor of the *Proceedings of the Academy of Sciences, Arts, and Letters* he established the *Great Basin Naturalist*. It began as volume one, number one, July 25, 1939, and has continued in unbroken sequence to the present day.

Vasco M. Tanner has long been an advocate and active supporter of conservation. Long before the term "ecology" became a household word, he and many of his associates and students preached the gospel of preservation of our natural resources. As a result of his working as a consultant of the United States Forest Service as well as other agencies, he has been influential in bringing much land, particularly along the Wasatch Front, under the control and protection of the Forest Service. Dr. Tanner has also been active in the State Parks Commission and in the National Parks Service. Closely associated with this activity has been his work in various civic enterprises which will be treated in separate articles.

Recognition of Dr. Tanner's standing in the scientific world is indicated by his membership in numerous scientific societies and in the fact that he has been granted a number of awards. He is a member of some fourteen scientific societies and is a fellow in five of them. He is one of few men in the western United States to be a fellow of the Royal Entomology Society of London. Special awards include the James E. Talmage Scientific Achievement Award, the Utah Academy of Sciences, Arts, and Letters Award in Biological Science, and Brigham Young University's Alumni Distinguished Service Award.

The major interest and contribution of Dr. Tanner has, of course, been in the area of teaching. If I were to name the most important characteristic of the successful teacher, I would say that it is to be able to inspire and stimulate his students. Vasco M. Tanner possesses

this ability to a remarkable degree. He was always interested in the great biologists of the past and took every opportunity to tell his students stories of their exploits and successes. To him David Starr Jordan, Louis Agassiz, Georges Cuvier, Charles Darwin, Jean Baptiste Lamarck, and a host of others of the past were figures of the greatest accomplishments, and he continuously stimulated his students to emulate them and to read their works. In the days when there were fewer students Dr. Tanner knew by name all of the pupils in his classes. If they showed the least interest in zoology or entomology he took a personal interest in them. Not only did he teach them, but he was concerned about their personal lives, their families, and their individual hopes.

Closely associated with Dr. Tanner's accomplishments as a scholar and teacher was his love of books and literature of all kinds in biology as well as in other areas. During his career he has assembled a personal library of thousands of books and reprints. Much of this material has found its way to the Brigham Young University library, but he still maintains much of this literature in his office and laboratory.

For his contributions to Brigham Young University as a scientist, teacher, editor, conservationist, and his inspiration to students, it is fitting that special recognition and tribute be paid to him in this issue of the *Great Basin Naturalist* on the occasion of his retirement as its founder and long time editor.

Following is a list of Dr. Tanner's publications to date:

1921
-22 The Bean Ladybird (*Epilachna corrupta* Muls.) Found in Southwestern Utah. Proceedings Pacific Coast Entomology Society 2(1):4.
1924 An Unique Blackbird. The Condor 26:192. Illus.
1925 Notes on the Collection of Fossil Fishes Contained in the University of Utah Collection with the Description of One New Species. Bulletin of the University of Utah 15(6):1-16. Illus.
1926 A New Species of Plastoceridae in the Genus Euthysanius (Coleoptera). Pan Pacific Entomologist 2(4):188-190. Illus.
1926 Life Zone Studies of Southwestern Utah. Utah Academy of Sciences 3:7.
1927 First Zoological Expedition of the Brigham Young University, 1926. Utah Academy of Sciences 4:23-24.
1927 Some of the Smaller Mammals of Mt. Timpanogos. Journal of Mammalogy 8(3):250-251.
1927 Notes on Birds Collected in the Virgin River Valley of Utah. The Condor 29:196-200.
1927 An Ecological Study of Utah Amphibia. Utah Academy of Sciences 5:6-7.
1927 Distributional List of the Amphibians and Reptiles of Utah. Copeia No. 163:54-58.
1927 Notes on Orthoptera and Dermaptera from Utah. Pan-Pacific Entomologist, 3(4):178-179.
1927 A Preliminary Study of the Genitalia of Female Coleoptera. Transactions of the American Entomological Society 53:5-50, pls. II-XV, 222 figs.
1927 A Preliminary Study of the Genitalia of Female Coleoptera. Abstracts of Dissertations for the Degree of Doctor of Philosophy, Stanford University, 4 p.
1928 The Coleoptera of Zion National Park, Utah. Annals of the Entomological Society of America 21(2):269-381. 1 pl.
1928 The Golden Eagle. The Utah Educational Review 21(6):4 p.

1928 Distributional List of the Amphibians and Reptiles of Utah, No. 2. Copeia No. 166:23-28.
1929 Future Human Progress. The Scratch, Vol. 1, No. 1. (A magazine published quarterly by the student body, Brigham Young University, 6 p.)
1929 Thomas Utting Spalding, 1866-1929. Entomological News 40:343-344.
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1929 Studies in Utah Orthoptera. (With Wilford Olsen), Utah Academy of Sciences 6:30-31.
1929 The Mexican Bean Beetle in Utah. Pan-Pacific Entomologist 5(4):183-186.
1929 Coleoptera of Utah—Cicindelidae. Pan-Pacific Entomologist 6(2):78-87.
1930 The Amphibians and Reptiles of Bryce Canyon National Park, Utah. Copeia No. 2(June 30):41-43.
1930 Fresh Water Biological Studies at Utah Lake, Utah. Utah Academy of Sciences 7:60-61.
1931 A Synoptical Study of Utah Amphibia. Utah Academy of Sciences 8:159-198, 11 pls.
1931 Fresh Water Biological Studies at Utah Lake—No. 2. Utah Academy of Sciences 8:199-203, 1 pl.
1931 A Preliminary Report on a Biological Survey of the Uintah Mountain Lakes. Utah Academy of Sciences 8:155-158.
1932 Ecological and Distributional Notes on the Freshwater Sponges and Bryozoa of Utah. Utah Academy of Sciences 9:113-115.
1932 Entomological Collections of the Rocky Mountain Region. Report of the Ninth Rocky Mountain Conference of Entomology, Pingree Park, Colo., August 15-20, 2 p.
1932 A Description of *Notolepidomyzon utahensis*, a New Catostomid from Utah. Copeia No. 3(October 7):135-136.
1933 Notes on Utah Lepidoptera. (With Owen M. Davis), Utah Academy of Sciences 10:151-152.
1933 The Genus *Salmo* in Utah. (With Sheldon P. Hayes), Utah Academy of Sciences 10:163-164.
1933 A Study of the Variation of the Dorsal Scale Rows of *Charina bottae* (Blainville). Copeia No. 2(July 20):81-84.
1933 Herpetological Note. Copeia No. 1(April 3): 42.
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1934 Studies in the Weevils of the Western United States, No. 1. Utah Academy of Sciences 11: 283-288.
1934 The Coleoptera of Zion National Park, No. 2. Annals of the Entomological Society of America 27:43-49.
1935 List of the Insect Types in the Entomological Collections of the Brigham Young University, Provo, Utah, No. 1. Utah Academy of Sciences 12: 181-193.
1935 Western Worm Snake, *Siagonodon humilis* (Baird and Girard) Found in Utah. Utah Academy of Sciences 12:267-270.
1935 Instructions for the Preparation of Competition Papers. Bios 6:334-335.
1936 Description of Two Melyrids from Utah (Coleoptera-Melyridae). Utah Academy of Sciences 13:153-54.
1936 List of the Insect Types in the Entomological Collections of the Brigham Young University, Provo, Utah, No. 2. Utah Academy of Sciences 13: 147-152.
1936 A Study of the Fishes of Utah. Utah Academy of Sciences 13:155-184, pls. I-III.
1936 A Study of Utah Fossil Fishes with the Description of a New Genus and Species. Utah Academy of Sciences 13:81-90.
1936 The Western Mockingbird in Utah. Utah Academy of Sciences 13:185-187.

1936 Shall We Adopt Means of Conserving the Wild Life of Utah? Utah Academy of Sciences 13:189-190.
1938 Phylum Arthropoda (Cont'd) Onychophora, Chilopoda and Diplopoda; Arachnida; Class Insecta; The Locust. Potter's Textbook of Zoology, pp. 286-358; figs. 161-206.
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1938 A New Subspecies of Worm Snake from Utah. Utah Academy of Sciences 15:149-50.
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1939 Introductory Note to Great Basin Naturalist 1(1):1.
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1940 Dr. Pfouts Contributes Butterflies. Great Basin Naturalist 1(2):61.
1940 The Flying Squirrel Collected in Garfield County, Utah. Great Basin Naturalist 1(3 & 4):126.
1940 John E. Blazzard Contributed Mammal Collections. Great Basin Naturalist 1(3 & 4):146.
1941 Studies in the Weevils of the Western United States. No. 4: A New Species of *Cimbocera*. Great Basin Naturalist 2(1):29-32.
1941 A New *Elaphrus* (Coleoptera, Carabidae). Great Basin Naturalist 2(4): 137-138.
1941 Painted Lady Butterfly in Migration. Great Basin Naturalist 2(2):104.
1941 Interesting Coleoptera Records for Utah. Great Basin Naturalist 2(1):36.
1941 Lesser Yellow Legs, New Record for Washington County, Utah. Great Basin Naturalist 2(2):86.
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1942 Sheldon P. Hayes Collects Cold-Blooded Vertebrates in Arizona. Great Basin Naturalist 3(2):59.
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1944 Dr. William Williams Henderson (1879-1944). Great Basin Naturalist 5(1-2):23-24.
1944 The European Earwig Found in Provo Utah. Great Basin Naturalist 5(1-2):22.

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1946 Some Aspects of the Conservation of Human Resources. Proceedings of the Utah Academy of Sciences, Arts, and Letters 23:117-124.
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1970 Mark Anderson, Public Servant, Conservationist, Forester, Author and Artist. Privately published, Provo City Dept. of Utilities. 6 p.
1971 Index. Thirty volumes, Great Basin Naturalist 31(1):

"I DO," INCLUDED A ZOO

Annie Atkin Tanner[1]

I married a zoologist, and the honeymoon had scarcely waned when I began to realize that I held only second place in my husband's interest—second place to every creeping, crawling, living thing.

His first love was a new species, be it a weevil, a reptile, a fish, or a bird. At first it was hard to believe that I was not essential to his happiness as I had so egotistically thought. Nothing was so important in his life as an infinitesimal insect, new to his collection.

My only consolation was his jubilant smile and enthusiastic conversation when, after many weeks, he received a letter from the Smithsonian Institution or the California Academy of Sciences, saying that a microscopic beetle he had sent them was a new species that would be named *tanneri* after him. This seemed prophetically significant. He gave me his name, but he also gave it to an insect.

Two years of married life added a Model T and a baby girl to our collection. My husband was a little disappointed when Carol defied the Mendelian law and had dark hair instead of sandy like his; there was also some sorrow that she wasn't a new collector. Despite this, defeat in a zoologist is never admitted, at regular intervals we added number two, three, and four girls before our only son was born.

It was when this son was very young that we knew he would never be a zoologist. Our local church was having a carnival and they asked our children to exhibit our snake collection as an attraction; and so the family reptiles were taken to the carnival.

The exciting moment came when the children were ready to go on the stage. Marilyn had a blow snake and a red-racer wrapped around her neck; Carmela's two black king snakes were wriggling rebelliously in her hand; and our son held a grass snake by the head.

The little girls performed like troupers, but just as four-year-old Jordan held up his snake for the audience to see, the perverse creature wound itself around his arm. With instinctive fear, he pulled the snake from his arm and threw it far across the stage into the wings, where it was retrieved by his chagrined father.

From that day on, my husband often looked at Jordan and then reproachfully at me and concluded, "I am convinced that environment in the home is a more powerful force than heredity." It was a subject we didn't mention, but both of us knew our son would never be a scientist.

As far as the family was concerned, the car we had saved money to buy was only a means of getting to a new place to collect. Our

[1]Mrs. Vasco M. Tanner, 70 East 800 North, Provo, Utah.

trips were always to the desert, the sand-dunes, or the brush land. There was not time in the zoologist's life for the canyons or the lakes.

On arriving at our destination, out from the trunk of the car came the cyanide collecting bottles, and the insect nets. Singing happily, my husband disappeared into the vastness of the desert.

The children hunted rocks or played hide-and-seek, but the day grew hot and the water in the canvas bag became sickly warm by noon—so warm that we could go without a drink rather than swallow this canvas-flavored liquid.

ANNIE ATKIN TANNER

In midafternoon the mosquitoes came, not in polite groups of a few hundred, but in plague-like multitudes. They swarmed over us, and my worries began, for no longer to me was the mosquito just a pest; he was the carrier of deadly malaria. I tried to watch each one that flew on the children to see if there were spots on its wings, for this I now had learned was the dreaded *Anopheles*—the female that transmitted malaria.

Just as dusk came on and I was worn out with fighting what I thought was my last fight with malaria, my husband returned to the car with the smile of a conqueror on his face.

We all gathered around him, while he showed us the success of his day's work. Carefully, with small tweezers, he took from the small gas chambers of the cyanide jars, a green tiger beetle, a red and black beetle, and a mourning-cloak butterfly. A large bottle filled with formaldehyde was the repository of a lizard, a rattlesnake or, perhaps a lowly centipede.

After we had admired and shuddered at these creatures of the desert, they were carefully stored away and the work of getting ready for the night began.

The children gladly ran to hunt rocks to anchor the tent poles; I bathed the baby in a pint of water in a tin washbasin and then came the process of cooking supper over a campfire. The children loved this part of the day; they lighted sticks in the fire and enjoyed the smoke-flavored hamburgers and fried potatoes. My joy came when they were peacefully sleeping, each in his own cot, with cool night breezes to refresh their tired little bodies. When this time came, I stretched out on my hard bed and breathed the fresh, cool air in quiet content. My contentment was short-lived, for soon my

zoologist had a card table up, all his bottles out, and his net leaning hopefully against the table. The car lights were turned on and then the desert became the gathering place for all the night insects. They came from far and near, attracted to their death by the bright lights. These insects, some of them, crawled on our faces, under our arms, and beneath the covers. They had a concert, bass beetles and mosquito tenors, and a deadly hum made the night hideous. I covered my head and the children restlessly hit at the bugs.

When I had come out from the covers for air, I pleaded with the entomologist to please turn out the lights, but he was so fascinated with his happy hunting ground that my entreaties were literally wasted on the desert air.

The exciting beauty of the early morning made us forget the invasion of the night before, and soon we were traveling the long, smooth miles toward home. The children and I were given instructions to watch the road carefully and report immediately if a snake should cross in front of the car. Suddenly one of the girls would scream, "Daddy, there goes a blow-snake," or "There goes a rattlesnake."

With a groaning of brakes and a heaving jerk, the car settled down and out jumped the collector. With a forked stick in one hand and a burlap sack in the other, the battle began. The children cried in fear that the snake might bite their father; I sat in grim wonderment, wishing that a snake had never been created. When this evil creature of Eve's downfall had been securely tied in the sack and placed between the two seats of the car below the children's feet, my husband settled down contentedly in the front seat. All the rest of the way home, we either listened to the hissing of one snake or the ominous rattle of another. I sat in uneasy fear lest one would escape and bite the children, who kept their feet on the seat all the way home.

One rainy night, on a vacation trip to the Grand Canyon, we had pitched our tent in the Kaibab Forest. All the family were asleep, but I couldn't close my eyes as I listened to the strange night sounds around me. The moaning of the wind in the pine trees, silhouetted against a lightning-splashed sky; the drip-dropping of the rain running off the tent and hitting on a tin can; the indescribable sound of some strange wild animal in terrible torment, made sleep impossible.

I sat up in bed; my throat tightened with fear as I looked at the burnt-orange coals of our camp fire. Around it were ten or more grotesque monsters with flat, fantastic heads and bodies like prehistoric lizards. I screamed, and my husband, who was snoring in his cot, jumped up and angrily asked, "What on earth is the matter?" I pointed to the fire and weakly asked, "What are those awful creatures?"

He began to laugh and calmly answered, "Why, those are harmless salamanders; they have come in out of the rain to get warm. Now will you please go to sleep?"

When I was sure our amphibian visitors meant no harm, my heartbeats slowed down, but soon I again heard that unearthly cry in the forest. I barely whispered, "Is that a mountain lion?"

"It is only a friendly hoot-owl. Will you let me have a little sleep before morning?" This was the comforting answer from the man in the nearby cot.

We all enjoyed Bright Angel Point in the canyon, but we spent most of our two days' vacation turning over the water-soaked logs and muddy rocks to look for the elusive beetle that was found only in this forest. The vacation, wet as it was, was considered a real success when we found one beetle new to western America.

We returned home dry and safe. I was glad the vacation was over; no more monsters, no more hoot-owls, no sand, no rain, and home meant clean white sheets and a warm bath. But all was not at peace at home; on the front doorstep was a wire cage with a rattlesnake shaking its rattles at us as we stepped near the cage. On the other side of the step was a shoebox with small holes punched in the lid. The girls were delighted when they opened the box, for there was a "beautiful, green grass snake." Marilyn, with the face of a young angel, took the snake fondly in her hands and smiled sweetly as the cold-blooded thing wriggled up her arm and coiled itself around her throat.

As I looked at her all I could think was, "Did I raise my child to be a snake charmer?"

In a few minutes the snake dropped to the floor of the living room and slithered itself under the davenport. I ran for the broom, but by the time I returned the snake had disappeared.

This was the "skeleton in our closet." For many months we searched our beds each night; and everyday I expected to see its lidless green eyes peer out at me from some dark corner. We never saw it again.

One day in September a neighbor's child was playing with a brown water snake, which slipped out of his hands and made good its escape.

From that day until the snow fell, that snake was always present. If I hung out the family wash, he peeked at me from behind a box or from a sheet on the line; so winter came that year with a real welcome.

Every year little boys and men bring huge, hairy, black tarantulas in bottles and I have to look at them until they are taken to the laboratory. Each spring frogs die in my fruit bottles; and summer finds turtles pastured on the back lawn. They always stretch their long, wrinkled necks to reach a dry leaf; I think they must have a nostalgic longing for the desert and have no appetite for grass.

Often at night I think of the low, black hills of my home town in southern Utah. On the slick, lava rocks of those hills, there was one huge boulder I called my rock of inspiration. From its solid foundation, I learned Lincoln's Gettysburg Address and "The Man without a Country." My high school friend and I always sat on it

to read "The Lady of the Lake" or "God's in His Heaven, All's Right with the World."

It was on warm, spring days that I wrote poems and dreamed of the wonderful things I would do. On winter days, I slept the hours of youth away on this rock in the southern sunshine. On the first days of April, I knew the joy of seeing the first orchid sego lily open its waxen petals and the cactus wren build her nest in the prickly pear tree.

When I first went to those hills with my husband, his collecting instinct made him forget to look at the river below, with yellow cottonwoods along its banks. He didn't even seem interested in my Rock of Inspiration. All he saw was the huge crevice in it, from which he pulled a yellow and black Gila monster, twelve inches in length. My paradise was lost forever.

My loved hills became, from then to now, the home of snakes, lizards, Gila monsters, and centipedes.

It has taken many years for me to concede that I have been defeated by an invisible army that is hidden under every rock, every bush, and in the trees and in "the waters under the earth."

Now I am quite reconciled to the fact that in Nature's plan, and in the mind of a zoologist, the female of the species is only important for the part she plays in reproducing the species. This part I have played.

VASCO M. TANNER — A PUBLIC SERVANT

Calvin L. Rampton[1]

It is a distinct pleasure for me to participate in this issue of the *Great Basin Naturalist* honoring Dr. Vasco M. Tanner. As Governor of the State of Utah, I want to add the gratitude of the people of Utah to the praises of his friends and colleagues.

Too often men of science eschew involvement in government, which is to be regretted, because it denies the public the services of some of its most gifted and resourceful members. This decidedly is not the case with Dr. Tanner, who has been an active participant in civic affairs throughout his distinguished scientific career.

He has been an active member of the Provo Chamber of Commerce for nearly forty years, and in 1932 was designated chairman of the chamber's Conservation and Forest Committee which played a vital role in conservation projects around Provo.

He has made a singular contribution to the implementation of the multiple-use concept in our national forests as a charter member of the Uinta National Forest Civic Advisory Council, both in acquiring new lands and in preserving those lands already in the public domain.

Dr. Tanner has sought to protect Utah's interests in the Colorado River Storage Project as a member of the legislative committee of the Five Upper Basin States.

In recent years, he has served the people of Utah as a commissioner in the Parks and Recreation Department, and in 1966 received the Conservation Education Award from the Utah Wildlife Federation for his outstanding contributions to the wise use and management of the nation's resources.

This remarkable man has served in elective as well as appointive office. He was a member of the Utah House of Representatives. He has developed wide ranging intellectual interests beyond natural science in the fields of history and religion, as his term as national president of the Sons of the Utah Pioneers attests. Certain Dr. Vasco M. Tanner's career epitomizes the ideal of professional and civic service.

I know I convey the gratitude of the people of Utah for his unceasing labors in their behalf and extend their best wishes for a continued vigorous and productive life.

[1]Governor, State of Utah, Salt Lake City, Utah.

VASCO M. TANNER — A PARTICIPATING CITIZEN

Verl G. Dixon[1]

Dr. Vasco M. Tanner is a great scientist who has excelled in his chosen field and given dedicated service to his community at the same time. Few people have the energy and the spirit for such achievement. It has been my good fortune to be stimulated by Dr. Tanner from college days in the late twenties and early 1930s to the present.

Perhaps the word *zest*, if combined with knowledge and dedication, would convey some of the impression he leaves with those who know him.

As the growth of Utah Valley began to surge, Dr. Tanner was one of the first to recognize potential dangers to the environment. This concern was expressed through his chairmanship of the Forest and Conservation Committee of the Provo Chamber of Commerce.

The construction of flood control works to be followed by contour retention construction and other conservation facilities are evidence of his persistent efforts.

A half century of research and teaching in the life sciences has been paralleled by equal time as a concerned citizen. Not only has Dr. Tanner worked to conserve the good things in our environment, but he has been devoted to building his community. As an original member of the Provo City Power Board and present chairman, he has contributed greatly to the growth and prosperity of our city. His good judgment and searching mind have been strong factors in building the more than ten million dollars of assets in the power department. This splendid utility has contributed over three million dollars to the general fund of Provo City. Superior service to the city at rates lower than power rates in the area is an indication of good management.

How Dr. Tanner has found time to do all he has been able to accomplish is a tribute to his ability to organize and carry out his plans. He has served in the State Legislature and was a member of the Utah State Parks and Recreation Commission during its years of greatest growth.

He served a term as president of the National Society of the Sons of Utah Pioneers from September 1962 to September 1963. He has always had a keen interest in preserving the heritage of the great basin area.

Through all his endeavors, Dr. Tanner has received the support and encouragement of his wife, Annie Atkin Tanner, and their children.

It is a signal honor to me to be asked to pay tribute to such a noble citizen, churchman, and educator. His dedicated service to community, state, and nation will stand as a perpetual memorial to Dr. Vasco M. Tanner.

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[1]Mayor of Provo City, Provo City Corporation, Provo, Utah.

VASCO M. TANNER — A DEDICATED PUBLIC SERVANT

J. Hamilton Calder[1]

My first acquaintance with Vasco M. Tanner was in September of 1936. He was the favorite professor of my cousin, Elma Robinson Allen. Elma insisted that I bring him to her wedding reception, and as a result we had the pleasant opportunity of each other's company to and from Salt Lake City.

On that delightful evening I was impressed with his interest in people and his vast knowledge of government, science, religion, and education. We touched on many subjects. The subject of highways provoked a discussion on Henry Blood, then governor of Utah. There was concern lest the governor's business and engineering background might cause him to neglect pressing social needs of the people of the state. At the Point of the Mountain geology commanded our attention for a few fascinating moments as the professor told of the receding of old Lake Bonneville and the formation of Great Salt Lake and Utah Lake which are connected by the Jordan River.

The wedding reception not only brought teacher and student together for an exchange of felicity, but it also afforded the pleasant opportunity of meeting some of Salt Lake's top society. I must say, Dr. Tanner was as much at home among the Republicans as I have seen him elsewhere among his beloved Democrats.

Our experience at the wedding occurred nine months after Mark Anderson had taken office as mayor of Provo. He was elected on a municipal power platform. The campaign, culminating in his election, and the events that followed attracted attention throughout the Intermountain area.

Mayor Anderson wanted more revenue for Provo City's empty coffers. Municipal power was the source. His opponents thought differently. A venture of this magnitude would bankrupt the city, and this prediction was hammered home by such able speakers as Dr. Adam S. Bennion and G. Ott Romney, both orators in their own right.

Lawsuit followed lawsuit but in the end Mark Anderson was the winner. He had promised the citizens of Provo a revenue-producing power plant operated by a nonpartisan citizen board of three members. The business community had opposed the move almost to a man. Where could three qualified businessmen be found to form the board?

In October of 1939 I received a call from the mayor saying he would like to see me as soon as possible. I met him a few minutes later. "Hamilton," he said, "I have just selected Dr. Vasco M. Tanner as a member of the new Electric Utility Board of Provo City and I want you to be a member of the same board. I have another businessman in mind as the third member. I selected you because of

[1]1074 Oak Lane, Provo, Utah

your age and business background; and I selected the professor because of his influence and dedication. It's a big job. You have the confidence and support of the city commission."

I remember that parting handshake and the deep feeling of inadequacy that possessed me at the time. I had no misgivings about the fiscal and operating responsibilities of the position, but I knew there would be political overtones, and it was here I felt insecure.

During December I spent two weeks in Kansas and Nebraska studying the operation of municipal power systems in those areas. Dr. Tanner made a similar trip at a later date. One of the most frequent statements I heard in talking to private citizens in many of the cities and towns we visited was, "You can make a success of municipal power if you keep it out of politics." I came back from the trip convinced of the wisdom of this admonition.

At my first opportunity I talked to Dr. Tanner about our experiences in the Middle West. I was relieved to find we were in complete agreement in the major areas of personnel and fiscal policy as well as operating autonomy.

While I don't recall we ever had a formal understanding of our respective areas of responsibility other than those designated by law, it was soon apparent Dr. Tanner was the one member of the board best qualified to handle public relations. He assumed this responsibility from the very beginning and he performed in this area with courage, with dignity, and with perseverance.

During more than thirty years of operation, Provo City Power has never put a man on the payroll for political reasons, and there has never been a case of nepotism. Dr. Tanner is largely responsible for this accomplishment.

Power was first generated and distributed to the citizens of Provo on April 1, 1940. During the hectic days from December to April the board met several afternoons each week, occasionally until midnight. Tempers were frequently strained, but of all the people under pressure it seemed Dr. Tanner kept his composure better than anyone. He was always cool and collected.

In his report to the board early in December of 1940 the superintendent predicted a net income of $100,000 for the first partial year of operation. He attributed this to the outstanding performance of the employees and recommended the board show its appreciation by giving each employee a turkey for Christmas. When the board hesitated to approve the expenditure, he informed us this was a standard practice in many municipal power cities. With this assurance turkeys were duly ordered for each employee and for the three board members.

On the evening of January 7, 1941, I received a curt telephone call from the mayor directing me to come forthwith to the city hall. My wife had just returned from the hospital with our firstborn. I left home reluctantly.

The mayor spotted me as I entered the city hall. The room was crowded with reporters and irate citizens. He motioned me to the front, and I responded obediently. He was white with rage. As I

stepped on the platform he shouted, "Calder (he usually called me Hamilton)! Tell these people why you gave the employees of the power department turkeys for Christmas." "Because they made $100,000 for the city and this was our token of appreciation," I answered. "Nonsense," he retaliated, "I thought you had better sense. You have brought disrepute not only to yourself, but to the entire city of Provo. There'll be no money paid out of public funds for this purpose. Goodnight."

As I found my way through the crowded aisle I could feel my emotions swelling within me. I was humiliated beyond description. Tears hampered my descent down the stairway into the darkness beyond. I opened the door expecting relief, but the cold January air shocked me from head to foot. Just then I heard footsteps and the next moment the strong arm of Judge Maurice Harding was around me. Never have I heard more comforting words as he spoke to me in the loneliness of that January night.

The Salt Lake and Provo papers headlined the incident the next day. Enemies of the mayor called me, urging retaliation. Things remained status quo until the next evening when the three members of the board met unofficially. A defiant attitude prevailed. What right has the mayor to embarrass us in this fashion?

It was Dr. Tanner who restored our composure. On his urging we called on the mayor at his home. He welcomed us and was visibly affected by our visit. The next day we reimbursed the city in full for the turkey voucher, each paying one third of the bill out of his own pocket.

Dr. Bennion and Ott Romney misjudged the capabilities of such men as Vasco M. Tanner when they predicted financial ruin for Mark Anderson's dream of a revenue-producing power department. In the years since 1940, Provo City has received $3,000,000 from this department for operation of the city government. Net income this year will approximate $1,000,000.

What is there, I ask myself, that distinguishes a man as an outstanding public servant? The answer is ability, honesty, and dedication. Dr. Tanner has all of these attributes.

VASCO M. TANNER - A GREAT TEACHER

Clarence Cottam[1]

In 1916, one year after obtaining his A.B. degree in zoology from Brigham Young University, Vasco M. Tanner began his teaching career at Dixie Junior College and High School in St. George, Utah. For four years during the time of his tenure there I was fortunate to be one of his young high school and later college students. I also followed him to Brigham Young University in 1925, where he had just become head of the Department of Zoology and Entomology after receiving his doctorate at Leland Stanford University. In both high school, college, and graduate work I took nearly every course he taught. I believe I was his first master's graduate. During a considerable part of this period I served as a laboratory assistant under him, and so I became privileged to know him well.

I found him a great teacher who had the unique and too uncommon ability to make his students see and feel the great enthusiasm he found in nature. Enthusiasm makes the difference between superior and mediocre teaching. A great leader is he whose magnetic power is such that he can make others, and particularly his followers, want to do what he wants them to do—and hopefully what they ought to do.

In the field, even more than in the classroom, Dr. Tanner was able to show that nature was a living, dynamic force that was always challenging and fascinating. His searching questions and encouraging suggestions of what one might find in nature gave me an insatiable desire and determination to study, discover, and understand as much as I could of her secrets and ways. Most of his students found that as their knowledge increased and their horizons expanded, their love and appreciation of nature increased.

We began to see and feel an interdependence of forces in the universe and, therefore, a genuine need for mankind to work in harmony with nature rather than to attempt control by going contrary to nature's ways. This concept is the basis for sound conservation. The more we learn of nature's laws, the more we find that they are inexorable and immutable and that they exemplify well the principles of cause and effect and law and order that are so evident throughout the universe. Violation of nature's laws—like the violation of society's wise rules and regulations of its code of ethics, morality and justice—cannot be indulged in with impunity. The misuse, waste, and pollution of land, water, and air will bring economic, social, cultural, spiritual, and physical distress and heartaches to a society that permits such abusive practices. My work in the field of conservation, teaching, and management of resources certainly had its start in the biological training I gleaned under the able leadership of Dr. Tanner at Dixie and BYU.

[1]Welder Wildlife Foundation, Sinton, Texas.

In my first course in high school biology, Dr. Tanner asked me what species of humming birds I had seen. To me they were all hummers, so I answered, "Little hummers and bigger ones and some had white throats and some with iridescent black and brilliant red throats." He answered kindly but challengingly asked, "What species are here?" and he added, "It will be a lot of fun to find out." Then he inquired, "What kind of flowers do they go to?" I could only reply that they came to flowers of different colors and I had seen them in flowers of different shades of red, blue, and white. He challenged me further by asking, "What do these tiny birds feed on?" I could only suggest "something inside the flowers." He then assigned me the task of finding out what I could about humming birds. There were few books on birds at that time in St. George and still fewer of those dealing with these diminutive but attractive creatures, so he reminded me that the best place to learn of them was out in nature; he appropriately added that nature's books were always open at the appropriate season.

I doubt that my esteemed friend and teacher has the faintest recollection of this little incident, and I am still more sure that any knowledge I imparted on this assignment was elementary indeed. Still, this challenging excursion into nature left an indelible impression on my mind. It has over the years made me ask many questions about nature's ways and her varied progeny: How do they survive and compete? What good or harm do they do? What relationship do they have to their environment and to other species? Why were they where I found them? How could they be increased, decreased, or controlled? What were the basic factors of their population dynamics?

In looking back on these rich, early experiences I feel that the most valuable training I received was on our summer field trips when we were away collecting insects, birds, rodents, and plants for the University. On these trips the graduate students were collecting and studying specific groups of organisms or problems for their respective theses. I was studying and collecting birds.

Students who participated will never forget such expeditions as those into northeastern Utah, the Bear Lake area of Utah and Idaho, and the Uinta Mountain area of Wyoming and Utah, especially the trip from Malta, Dagget Co., Utah, over the high mountains to Vernal and Dinosaur Quarry. I believe we deserve the distinction of taking the first car over this rugged and steep mountain sheep trail. Our group consisted of Dr. Tanner, C. Lynn Hayward, C. J. D. Brown, and Clarence Cottam. Then, we agreed that the assertion of our "taking" the old Model T, the "Beagle," over the mountain was more accurate than to say that we traveled in it. This so-called road had never been used for anything more than a sheep or cattle trail and certainly was not designed for an automobile, particularly those ancient Fords, for many times our vehicle had to be pushed or almost carried.

Because of the steep and rough "roads," we were several days making the trip. Before we reached the summit of the mountain,

our provisions ran out. The last day of our climb had been slow and difficult and the distance traveled was but a few miles. We were all tired and hungry and the sum total of our provisions consisted of one small can of tomatoes! It was nearing sundown. We decided to push on and go over the next ridge to see if we could find a mountain stream where we could camp for the night. We expected, of course, that we would have to live off the land until we reached Vernal, hopefully a day or two later. At about dark, when we were wishing our wives or mothers had us, we entered a delightfully beautiful alpine meadow and to our great delight encountered a sheepherder and his flock bedding down for the night.

The bearded sheepherder had been in the mountains alone with his sheep for nearly a month; and without radio or other communication from the outside world, he was nearly as glad to see us as we were to see him. He remarked that it was an enlightening relief to have something besides his dog and sheep to talk to. When he learned that we were about starved, he promptly killed a near grown fatted lamb, made dough biscuits, and with some choice canned goods saved for special occasions, he soon had us feasting on one of the most appreciated and tasty meals any of us can still remember.

Another memorable trip was that to the "Four Corner" area of Utah, Arizona, Colorado, and New Mexico. In the group were my older brother, Dr. Walter P. Cottam; his graduate student, Sealer Hutchins; along with Dr. Tanner and four of his students, D. I. Rasmussen, Anson Call, James Kartcher, and Clarence Cottam. We spent a day near Mesa Verde National Park and another day in the scenic mountains and Natural Bridges west of Blanding.

Still another never-to-be-forgotten trip was on the Arizona strip north of the Colorado River when we unexpectedly ran on to a wild herd of possibly 35 or 40 buffalo. We shall long remember the sleepless night we camped out at the historic Lee's Ferry on the north bank of the Colorado, deep in Marble Canyon. The mosquitoes were in swarms and the night was painfully hot and sultry, yet we had to cover up to get some protection from the mosquitoes.

The next day we traveled only about 15 or 16 miles, from about 2,500 feet elevation to over 9,000 feet up on the north rim of Grand Canyon where we were as uncomfortably cold that night as we had been hot the night before. We then learned that in biological and ecological studies, we must give most consideration to the extremes and not the means. The high temperature in the deep canyon of perhaps 110 or more degrees and the rare atmospheric temperatures of perhaps less than 50 degrees may give a comfortable average, yet the two extremes of heat and cold were both painfully uncomfortable.

These experiences now afford a lot of pleasant memories, but then they taught us all something of the meaning of conservation, ecology, and the interrelations that inevitably are an essential part of nature. My appreciation for nature and the broad open spaces was whetted and stimulated and at least partially matured under the skilled tutelage of my esteemed friend and teacher, Dr. Vasco M. Tanner. I shall ever be gratefully indebted.

VASCO M. TANNER — A PIONEER IN CONSERVATION

Walter P. Cottam[1]

To be invited to contribute to this commemorative issue of the *Great Basin Naturalist* honoring the life and labors of Dr. Vasco M. Tanner is a distinct honor for many of his old associates who witnessed the birth of this scientific journal and know that Dr. Tanner was the father of the idea and the midwife at its delivery. Most important, it was he who nurtured the infant journal, successfully rearing it to become an informative and influential disseminator of biological knowledge to both scientist and layman throughout the Great Basin and far beyond these borders. Such accomplishments alone should elevate this man to a prominent niche in the Scientific Hall of Fame, but in my opinion his accomplishments as a teacher and department head at Brigham Young University far exceed those as the founder and publisher of a successful new journal.

It was in Dr. Tanner's role as scholar, teacher and field researcher that he most intimately touched my own life. Both of us were graduates of BYU, and by the midtwenties both were members of the BYU faculty, he as a zoologist and I as a botanist. Each of us headed departments and each comprised the teaching staff of these two large biological fields until the late twenties. During these years our association was most intimate because we had agreed upon joint field trips with a number of our most promising students, and we spent almost two complete summers in the hinterlands of Utah, where Model T Fords were a good match for the roads of that day, and where the fauna and flora along them remained unknown and largely unrepresented in the meager biological collections in our universities. These were fruitful and gloriously exciting months under the open sky that glows away from civilization.

Under such circumstances of semisolitude brought about by our temporary removal from the "petty ill concerns and duties" generally attending the captive city dweller, this small group of students and teachers experienced an extraordinary solidification of friendships that surely can never perish in the flesh. I feel that none of us can ever forget the nightly impromptu forums held under starlit skies or around the campfire where all appropriate subjects were limited only by our competence to discuss them. Most frequently these discussions were stimulated by our observations of the day, but time after time they ended with the consideration of some aspect of the conservation of our intricate biological resources. The late twenties were years when much of our beloved Utah landscape was raw with sores resulting from decades of grazing abuse and from the damaging drought of 1898-1904. Dr. Tanner's demonstrated knowledge of the cause and effects of wild land deterioration was an

[1]1114 McClelland St., Salt Lake City, Utah.

inspiration to us then, and a prophecy of his attitudes and activities in conservation during the decades to come. It can be safely said, I believe, that few voices have been raised in Utah with such force, with such clarity, or with such authority on the nature of our resource problems and their solutions. The marvelous rehabilitation measures applied by the Forest Service to the high Wasatch Mountains east of Provo, in the vicinity of Provo Peak, were in large measure stimulated by this wise and good scientist. Our great governmental agencies such as the Forest Service, the Bureau of Land Management, and the Park Service—all charged with the responsibility of managing and conserving the priceless heritage of our wild lands—are cognizant of Dr. Tanner's eminence in the field of conservation and freely seek his advice.

TRIBUTE TO VASCO TANNER

Bertrand F. Harrison[1]

The time was the mid to late nineteen twenties. The members of the faculty in the biological sciences at Brigham Young University could be comfortably enumerated on the fingers of one hand. Science libraries were few and those that existed were anemic from undernourishment. Research activities were underway but as yet there was only a dribble of research, and still less found its way to the printed page. Research then in progress was, perhaps by necessity but more because of urgent need and because of the magnificent opportunity at hand, confined to descriptive field work. Such was the picture when Vasco Tanner joined the faculty of Brigham Young University.

Dr. Vasco Tanner brought with him a strong conviction that the growth of a science required the ready availability of pertinent scientific literature. He consistently preached this belief to students and colleagues alike. He expressed his zeal for building bibliographic resources by working to strengthen the University library and by beginning the accumulation of what was to become a substantial personal library.

Interest in scientific literature did not stop with his desire to build and to accumulate. He had a critical sense of that which was good. Further he had the ability to express in literate prose the results of his growing personal research program. His expertise in writing and in judging the writings of others served the Utah Academy of Sciences well for the many years he served as secretary and editor of the *Proceedings*. Upon his termination in this position he founded the *Great Basin Naturalist*. He has served as editor of this journal from its founding until the present.

My acquaintance with Vasco Tanner began just after he joined the Brigham Young University faculty, while I was still a student. A few years later, when I joined the faculty, our work and common interests brought us closer together. Thus began a long and rewarding friendship.

The statement that we were "brought closer together" was literally true. We shared one set of student microscopes between us. The general botany laboratory sections and the general zoology laboratory sections were scheduled on alternate days, and our single set of microscopes was transported back and forth each day to serve for study of animals one day and for the study of plants the next. Other items of laboratory and field equipment did double duty, serving students of both departments. Under such conditions cooperation rather than isolation became the only feasible working relationship.

Dr. Tanner was always generous in sharing, whether it was an item of equipment belonging to the Zoology Department or a book

[1]Department of Botany, Brigham Young University, Provo, Utah

from his personal library. Similarly, he was always willing to share his time, to find a literature citation, to identify an insect, or to suggest solutions to a problem.

For me, the sharing of material things, while necessary and helpful, was secondary to Dr. Tanner's willingness to give of himself. At a time when biologists in the intermountain area were few and widely scattered, our opportunities for discussion of principles and patterns of thought were very limited. Hence, the privilege of having someone else to talk with, to test out hypotheses against another's thinking was worth much.

From my many years of association with Vasco Tanner I have developed a great respect for him, for his personal interest in his students, for his contributions in several fields of zoology, for his editorial work on several journals, for his interest and effective work in conservation, and for his service to his community. I wish to add my commendation for the great service he has given others.

SOME MEMORIES AND IMPRESSIONS OF MY ASSOCIATION WITH VASCO M. TANNER

John E. Blazzard[1]

I have been an acquaintance, a student, and an admirer of Dr. Vasco M. Tanner for the past forty-eight years. I was a student of his at Dixie College in the fall of 1921 and later lived for a time as his next-door neighbor.

I returned to Dixie College after four years out of high school and had the privilege of taking classes from Dr. Tanner in geology, botany and other biological sciences. From him I received stimulus to direct my studies in the sciences of the great outdoors. After two years at Dixie, I graduated with an Associate of Science degree. I then took my family to the deserts of California to earn money for further college work.

It was in the summer of 1925 that Dr. Tanner again came into my life. He had just received his doctorate from Stanford and he was en route to Brigham Young University to become head of the Department of Zoology and Entomology. He and his family called to see me. It was at this time that he invited me to come to the Y as his assistant. I did so in September 1925.

When I arrived, I found Dr. Tanner already established and mixed up in the dust and disarray of many years' accumulation and neglect. His office, assigned classroom, and laboratory space were on the second floor of the old main building, overlooking the fountain on the front lawn. This was the start of a new department of zoology and entomology at BYU.

As I remember, this beginning was in unequipped, poorly arranged, and to some extent unused office and classroom space. The equipment and laboratory space were in a poor state of repair and were dusty, dirty, and mostly unused. I well remember that when I arrived, Dr. Tanner was busily engaged in collecting natural history specimens and other items that were scattered throughout the various departments on campus. Such zoological and entomological specimens at the Y at this time were more or less of the "museum" type and ill prepared for scientific study. They were in a poor state of preservation and very much neglected.

I was immediately assigned to the task of salvaging as much of the specimen material as could be usable again and disposing of the dusty, dry, unusable balance.

Laboratories and classrooms were developed; and with the energy and foresight provided by Dr. Tanner, they served very well for the beginning of a new department.

From this meager beginning Dr. Tanner soon added equipment and personnel to carry on the work of the department. He soon had

[1]439 South Main, Logan, Utah.

about him a fair-sized group of students who were eager to pursue studies in the sciences of the great outdoors. Those whom I remember were C. Lynn Hayward, Clarence Cottam, Lynn Alleman, Ray Van Leeuven, Bliss Finlinson, George Marler, Claudius Brown, and D Elden Beck.

I left my duties with Dr. Tanner during the summer of 1926 to add further to my material needs. During that summer I collected insect specimens for my personal collection and that of the University. Upon my return in the fall, I found things really humming. Laboratories and classrooms had been remodeled and rearranged, greatly changing the appearance of things from the previous winter. In addition, another assistant had been added, Clarence Cottam.

During each of the two winters, 1925-26 and 1926-27, I conducted laboratory classes in zoology. I also prepared new zoological specimens, pinned new insects, and learned to prepare mounts of small animal specimens.

I graduated in the spring of 1927. I received an appointment, with the help of Dr. Tanner, as district agricultural inspector in southern Utah. My district consisted of Washington, Iron, Kane, Garfield, Beaver, and Millard counties, with headquarters at Cedar City. In this large area I had ample opportunity to collect insects and small animal specimens. In the following eight years I collected and mounted eighty-seven specimens of rodents of southern Utah. During this period Dr. Tanner occasionally called on me while on some of his field trips and gave me information and help in this work. Through contacts made by Dr. Tanner, Dr. E. Raymond Hall of the Museum of Vertebrate Zoology, University of California, called to see me and offered to take my collection with him to be identified. All specimens were identified by Dr. Grinnell and were returned to me, except for two specimens which had not been collected before in this area. I occasionally displayed and discussed my collection at schools and other places where knowledge of it would be beneficial.

I moved to Logan in 1938 and finding it difficult to properly care for my specimens, I wrote to Dr. Tanner and offered them to Brigham Young University. On one of his visits to Logan, Dr. Tanner picked them up and added them to the collection of rodents at BYU.

Dr. Tanner has always occupied a spot foremost in my regard for my fellowman. As I look back on my association with him, I remember him as one having a firm purpose in life from which he never seemed to deviate. His day's work was always programmed ahead so that one could depend on what he would be doing at a given time. As I have followed his later accomplishments, this indeed has been the pattern of his life.

As one of the thousands who have received stimulus and guidance from Dr. Tanner, I voice my deep appreciation for what he has done for me. Through his direction and guidance I have gained a deeper appreciation and understanding of those things about me which have added to my full enjoyment of life.

VASCO M. TANNER - AN INSPIRING TEACHER

Kenneth L. Duke[1]

My first contact with Dr. Vasco M. Tanner occurred during the spring quarter of my freshman year at Brigham Young University. I had registered for "Zoo 11," and Dr. Tanner taught the course, as he did all the other zoology courses offered at that time—since he was "the department." This association was very formal and distant and he was just one of many professors inflicted upon freshman college students.

By the end of this first year of college I was thoroughly confused as to the direction I should take for any future training. I had entered college with the idea of going into chemistry, but two quarters of the subject, in spite of Dr. Maw and his "little flower in the crannied wall," convinced me that chemistry was just not my thing.

A two-year mission for the Church, accompanied by some reading and much thinking and reevaluating of my interests and abilities, led me to consider a premedical curriculum. This decision was tentative and never actually materialized, but did set the stage for more contact with Dr. Tanner. There was comparative anatomy (I was just a year or two late to have the thrill of seeking out and capturing a stray [?] cat and "refrigerating" it on the window ledge of the zoo lab in the old Education Building), embryology (taught during the spring quarter when there would be an abundance of fertile hens' eggs, since each student had to furnish his own supply), and histology. Although I did not realize it at the time, I was rather definitely committed to zoology by the end of my sophomore year.

"The Doc," as he was affectionately called by those of us who considered him to be our boss, exhibited an enthusiasm in his teaching that affected all of us. No one could soon forget his manual demonstration of the formation of the heart in the chick embryo and the initiation of the heart beat, nor his straight-faced assignment of several pages of outside reading in *each* of a hefty pile of books which he so obviously carried in and deposited on the lecture table as a preamble to his lecture. And we believed him! Well, at least for a while. In some of the more advanced courses (cold-blooded vertebrates, research seminars, etc.), Dr. Tanner used to describe the organization, logistics, and results of some of the early field trips made by him and his students to various parts of the state to study sites and to collect specimens for research. In speaking of a trip to the Henry Mountains area he waxed poetic and quoted: "The night has a thousand eyes; the day but one." I was to appreciate the meaning of the quote some twenty-five years later.

The thing that impressed me most about Dr. Tanner was his willingness to treat a student as an individual and to take the time

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to talk over ideas—biological, philosophical, social, or personal. He made you feel that zoology was an important and fascinating subject and that you could make a contribution to it. As a result of his inspiration and encouragement I left BYU, with an A.B. degree, and entered Duke University to do graduate work.

Three years later, with graduate studies completed, I began to formulate a long-range research project: a comparative histological study of mammalian ovaries. Where could a variety of mammalian genera be obtained to initiate such a study? As I pondered this question, sites such as the Henry Mountains, the La Sals, the Uintas, the West Desert kept coming to mind. So in 1946, about ten years after Dr. Tanner had introduced me to the biological bonanza that existed in the State of Utah and that awaited study, and each year since (with a few exceptions), an annual safari has departed from the Brimhall Building for field trips to various parts of the state: Mt. Timpanogos, Mt. Baldy, the La Sals, Castleton, Dead Horse Point, the Arches, Montezuma Creek, Elk Ridge, Hog Wash Canyon, Cottonwood Wash, Cock's Comb, Brian Head, Puffer Lake, Joy, Bonanza, Strawberry Canyon, Wasatch Plateau, Uinta Canyon, and in 1970 the Raft River Mountains. More material than can be studied in one man's lifetime has accumulated from these trips.

Unfortunately for me, Dr. Tanner has never been able to take part in any of these trips. However, some of his former students and colleagues (Drs. C. Lynn Hayward, Elden Beck, and Dorald Allred) initiated me well into the rigors, the rewards, and the joys of getting into the field and studying biology in its natural setting. And on the trip to the Henry Mountains area in 1963, as I looked up from my sleeping-bag into a black sky spangled with a thousand blinking stars, and as I listened to the peaceful biological sounds of the desert, I understood and appreciated Dr. Tanner's quotation: "The night has a thousand eyes; the day but one."

I shall ever be grateful for the interest, encouragement, and ideas that Dr. Tanner gave me while a student at the Y and for the part he played in directing me toward a most satisfying and rewarding career in teaching and research.

TRIBUTE TO DR. VASCO M. TANNER

Andrew H. Barnum[1]

One individual stands out in the education of any student. One instructor consistently plays the important role in influence and encouragement. That person in my life is Dr. Vasco M. Tanner, one of the great naturalists.

My personal recollections of Dr. Tanner extend nearly a quarter of a century. My life is more meaningful because of our associations.

My early impressions as an undergraduate student in entomology are filled with memories of his contagious smile, of the regimentation of his laboratory classes, of the high quality of work he insisted upon. Recollections focus the exactness of laboratory exercises, including carefully executed drawings. Only ink drawings received full credit. He had to do it for David Starr Jordan and we had to do it for Dr. Tanner. More than one outstanding scientific illustrator had a beginning and encouragement in Dr. Tanner's classes.

The students referred to him endearingly as "the wooly lamb" because of his curly hair and robust size.

His knowledge and his association with the world's great scientists made the history and literature classes live. As a book collector, Dr. Tanner had access to the important early publications, and in each history or literature class he would present to the students armloads of books with the admonition and advice, "Now I want you to become acquainted with all of these"; but at the close of the class period he would quickly gather up all the books, transport them to his office before they could become soiled, and lock them in a cabinet, secure for the next class.

He was very helpful to both graduate and undergraduate, always liberal with supplies for collecting. However, before dispensing the ethyl alcohol he would invariably add a little formaldehyde, always with the explanation that it made a better preservative. All along we knew he was just preventing us from adding our own ingredients for a different purpose!

Only the privileged graduate student had the opportunity of accompanying Dr. Tanner on field trips, and no one has really known him who didn't spend a week or two in the field, where the education in natural history was continuous over twenty-four-hour periods of exposure. It didn't matter whether we were treating the water with rotenone to collect fish (an occasional trout that didn't survive invariably wound up in the frying pan at night), rock-rolling in search of reptiles, or wading the streams for amphibians, we always collected insects. Frequently, too, we listened to more western history than natural history. Dr. Tanner was an avid first-edition book collector, and the student would often spend more time

[1]Dixie College, St. George, Utah.

waiting in the carryall for him to search for old books than he did in the field.

One eventful trip through the western states carried us into St. George where for many hours we relived his early teaching experiences at Dixie College. We walked the environments where he did his early collecting as a young biology instructor. (Dr. Tanner was instrumental in starting a natural history museum at Dixie College, where many of the specimens he collected can still be found. Several bird skins as well as other vertebrates, and many of the insects are still on deposit.) We became acquainted with the areas where he courted his sweetheart Annie Atkin, now Mrs. Tanner. He was especially fond of Water Cress Springs (now a part of the Dixie Red Hills Golf Course), as were the countless courters before and after him.

The evening we camped at the Nevada Warm Springs to try to obtain some of the native warm water daces, he was surprised to find no signs of the fish. While he was busy cooking dinner, I continued to investigate the waters where there was no sign of life, not even aquatic invertebrates. Before returning to camp I resolved that the waters had been poisoned, eradicating all animals. "Oh, no, that's not possible," he responded. Early the next morning Dr. Tanner arose, stretched, and made a pronouncement: He had been thinking all night. He had decided that these waters had been poisoned. Major professors are fallible, too!

No one could spend two decades in a close association with Vasco M. Tanner without gaining an appreciation of nature. Here is truly one of the great naturalists. Unfortunately, higher educational institutions are not now training naturalists, and they may soon be forgotten, lost because of specialization.

My tribute is written of a great naturalist, educator, and friend. I sincerely hope I have communicated memories for the countless graduate students who look longingly at their associations with one of their great instructors. We will always remember the "little wooly lamb."

VASCO M. TANNER — A LIFETIME WITH BEETLES

Hugh B. Leech[1]

Only someone with an inborn love of a subject is still enthusiastically working at it after more than fifty years of study in the field. Such is Dr. Vasco Myron Tanner, by 1916 a keen collector, interested in the darkling beetles, Tenebrionidae. Certain species of *Eleodes* were causing damage in Utah grain fields, and Dr. Tanner's reaction to this challenge in economic entomology shaped his own future: he began a correspondence with Dr. Frank E. Blaisdell, Sr., authority on North American Tenebrionidae. When he went to Stanford University to work for his Ph.D., Dr. Blaisdell, professor of surgery at the Stanford Medical School in San Francisco, encouraged him, helped greatly in providing rarities needed for thesis work, and introduced him to the collections of the California Academy of Sciences. This was the beginning of his long association with the institution. There he met Dr. Edwin C. Van Dyke, dean of West Coast coleopterists and specialist in weevils, Curculionidae, the second group of beetles which has provided a main impetus to Dr. Tanner's taxonomic research. So those pest *Eleodes* motivated not only continuing studies of two important groups of desert beetles, but also lifelong friendships.

Entomologists are familiar with Dr. Tanner's publications on Coleoptera, but they may not realize that he has done an equal amount of work in herpetology. In truth he is one of the old-time broad naturalists—he is interested in all animals, and through his biological surveys he is perforce experienced in botany.

In addition to descriptions of new species, Dr. Tanner's knowledge of the darkling beetles has resulted in a revised checklist of the North-American species of *Eleodes*, and (with Willis A. Packham) a study of the desert Tenebrionidae of the Nevada Test Site of the United States Atomic Energy Commission.[2,3] He began to publish articles about weevils in 1934 with descriptions of new species; a study of the subtribe Hydronomi appeared in 1943; one on the weevils of the Nevada Test Site, in 1966; and he has completed but not yet published a large paper on the North-American species of *Sitona*. He has also published work on *Scythropus*. These reports have been complemented by two important weevil collections at Brigham Young University: that of Charles Schaeffer in 1935, and that of C. W. Leng.

In the Curculionidae Dr. Tanner has not been held to North America. Largely as a result of their enthusiasm for collecting, many

[1]Associate Curator of Insects, in charge of Coleoptera, California Academy of Sciences, San Francisco.

[2]A check-list of the species of *Eleodes* and descriptions of new species (Coleoptera-Tenebrionidae). Great Basin Nat. 21(3): 55-78, 10 figs. October 2, 1961.

[3]Tenebrionid beetles of the Nevada Test Site. Brigham Young Univ. Sci. Bull. Biol. Ser. 6(1): 1-44, 22 figs. February, 1965.

of Dr. Tanner's students have contributed numerous insects, reptiles, etc., from the South Pacific, to the University's collection. While Dr. Beck and others were stationed on the Pacific Islands during World War II, they made good use of their spare moments by searching for specimens to send to their alma mater. They were especially successful in collecting the beautifully colored celeuthetine weevils, thus enabling Dr. Tanner to produce a finely illustrated study of the Solomon Islands species in 1969.[4,5]

Under the direction of Professor G. F. Ferris he completed his Ph.D. dissertation on morphology at Stanford University. Published in 1927, it is still constantly referred to in the literature as the major work on the genitalia of beetles.[6] His Stanford training in morphology is evident in his taxonomic papers, but one should not infer that his interests are narrow. He began as early as 1916 collecting every beetle in sight while on family and other outings in Zion National Park. He then compiled a list of the Coleoptera of the park (1928, with a supplement in 1934).

Dr. Tanner's extensive field work led to several biological surveys of areas in Utah, including that of the La Sal Mountains in coauthorship with Dr. C. Lynn Hayward. Started, but not completed as a unit, was a proposed series on the Coleoptera fauna of Utah and portions of the Great Basin; the first part dealt with the tiger beetles of Utah.[7] A corollary to his pleasure in the fauna and flora of the state is his long-time interest in the history of Utah and in the naturalists who have worked in it. Tied to this are the informative and appreciative obituaries of coleopterists he has published, recording information not otherwise available. A trip to England in 1957 to study types of weevils and other beetles at the British Museum enabled him to make a pilgrimage to the site where Linnaeus did so much of his writing, Linnaeushof. From this we have a very useful article, "Carl Linnaeus' contributions and collections."[8]

Dr. Tanner has described about sixty-five new species of beetles, and one new genus. I am aware of five species which have been named by others in his honor. He has, of course, expressed opinions as to synonymies, given keys for identifications, and made several of his papers exceptionally valuable by including excellent figures of whole beetles and their parts. It pays entomologists to study his publications in other fields; for instance, he has listed many beetles, other insects, and crustaceans found in the stomachs of Utah amphibians.[9]

Another phase of Dr. Tanner's work as a coleopterist is his founding of the journal, the *Great Basin Naturalist*. He saw the need for a regional outlet to cover a broad field, and of course wanted a source of publication for his own papers! The whimsical comments of that

[4]A study of the weevil tribe Celeuthetini of the Solomon Islands (Coleoptera: Curculionidae). Brigham Young Univ. Sci. Bull. Biol. Ser. 10(3): [1 +]1-46[+ 2], front. map, 40 figs. June, 1969.

[5]D. Elden Beck (1906-1967). Great Basin Nat. 27(4):230-239, 1 fig. December 30, 1967.

[6]A preliminary study of the genitalia of female Coleoptera. Trans. Amer. Ent. Soc. 53(1900): 5-50, pls. II-XV. March 25, 1927.

[7]The Coleoptera of Utah — Cicindelidae. Pan-Pacific Ent. 6(2):78-87. December 12, 1929.

[8]Carl Linnaeus' contributions and collections. Great Basin Nat. 19(1):27-35, 1 fig. May 30, 1959.

[9]A synoptical study of Utah Amphibia. Utah Acad. Sci. 8:159-198, pls. VIII-XX. July 1931.

most experienced entomological editor, the late Clarence H. Kennedy, in a review of the first issue[10] are still pleasant reading:

> This is an ideal publication of the kind that most editors succeed in producing only in their dreams, say at 3:45 A.M. Theoretically the editor, the contributor and publisher are in complete accord. The editor of The Great Basin Naturalist is Professor Vasco M. Tanner. The three articles and page of "Notes" are by Vasco M. Tanner and the publisher is Vasco M. Tanner under guise of the Department of Zoology and Entomology of Brigham Young University. We hope that the next time we meet Professor Tanner, as one editor to another, he will give us the "low down" on any differences of opinion that may have arisen between the editor and the chief contributor. Then, too, a publisher can be irritating at times. Furthermore, there is that special case of the law of diminishing returns which states that: "The good die young." We cannot believe that such a perfect journal can last long, at least in its present form. Perhaps it can metamorphose and come up tough and enduring, a true product of the desert whose fauna it discusses. . . . The quality of paper, general design and printing are excellent. The ANNALS wishes The Great Basin Naturalist the prosperous future that such pioneering deserves. . . .

In fact, the journal has far outdone Kennedy's hopes for it, another feather for the versatile Dr. Vasco Tanner, a coleopterist who successfully wears many caps. More power to his elbow and sharp eye.

[10]Book notices. The Great Basin Naturalist, Vol. 1, No. 1 Ann. Ent. Soc. Amer. 32(4): 779-780. December 16, 1939.

VASCO M. TANNER — A DIVERSIFIED CAREER

James W. Bee[1]

I consider it an honor to contribute some personal recollections as a former student of Professor Vasco M. Tanner. In spite of the lapse of a quarter of a century, my recall of his influence on students and his scientific devotion to research is clear. It is an honor to share his own pleasure and pride.

Cognizance of his name came prior to my academic days at Brigham Young University. Through conversations with my father, I learned interesting experiences of young Tanner as a member of a survey team.

At the University my greatest motivation in science was a course by Professor Tanner entitled "The History of Science." At that time he had attained public recognition in the field of zoology and entomology and was able to ascertain without prejudice, those facts of history that were of fundamental importance and to document the true origins of ideas. He also showed cause to respect the scientific method. His knowledgeable interjections brought out in living likeness the personalities of great scientists, and he demonstrated their widely varying dispositions and circumstances, while sharing a common interest in their search of truth. One of the delights of the course was his relating of experiences with his early colleagues, a group of great naturalists not likely to be assembled again in one zoology department. He persistently encouraged reading of great books, emphasizing that knowledge is power. He also taught many other subjects which added immeasurably to one's pleasure of living and gave one the feeling of a more intimate relationship with the flora and fauna and the physical features of Utah Valley and its environs.

In addition to being a great teacher, Professor Tanner developed significant natural history collections; while these collections had already reached the position of first importance before I entered the University, they continued to grow from year to year. His collections were the source material and inspiration for his research and publications. He will forever remain an example for his acumen to inspire funding authorities with the importance of acquiring scientific specimens and research material for graduate students and faculty.

To see Professor Tanner continually at the microscope studying the elytra of *Aracoschizus airmeti* or perhaps counting dorsal rays of *Knightia copei* prompted the uninformed to believe that his interests and knowledge of life did not extend beyond the specimen; however, second thoughts demonstrated that Dr. Tanner was a man whose varied and intellectual life was that of a truly creative thinker. Beyond the University sphere, he valiantly entered the controversial debates of conservation, preservation of natural resources, and poli-

[1]Department of Systematics and Ecology, University of Kansas, Lawrence.

tics. When meeting with prominent people during his extensive travels, being widely read, he was able to discuss at length, both intelligently and logically, any topic.

A scrupulous honesty pervades both his private life and his scientific writing. The soundness of his conclusions and enduring quality of his research are a tribute to the breadth of his vision, the thoroughness of his methods, and the excellence of his judgment. The high standard, both in matter and appearance of the journal that he founded and edits, owes much to his expert care and sound judgment. He has an unusual expertise as a discriminating and unprejudiced critic of manuscripts submitted for publication.

As I spent considerable time in the office of Professor Tanner cataloging and labeling his library of zoological literature, I was impressed with the great number of scientists and friends who came to visit him. They all derived pleasure and inspiration from their visits.

My acquaintance with his fine family was mainly through their visits at his office. I received glimpses there of the deep, tender affection and reverent regard he holds for his wife and family.

It is always a pleasure and inspiration to visit and chat with this fine gentleman. I regard my association with him as a highly important part of my scientific education and thank him for his continual concern for my career.

VASCO M. TANNER — COLLEAGUE AND FRIEND

George H. Hansen[1]

The Vasco M. Tanner and George H. Hansen families first became acquainted at Brigham Young University in the fall of 1927. At that time, several academic departments were one- and two-person teaching departments and were housed on lower campus. Zoology, Botany, and Geology were in that category.

Dr. Tanner was not only a good teacher, but he also found time to keep very busy collecting life specimens in the Great Basin area. Regional ecology was a part of his interest then, and it remains so today.

His small-group field trips made a lasting impression on all students who took advantage of them. These field trips somehow impressed us with a great truism in nature. The story of the rocks of the area and the life stories of plants and animals seemed to unfold into a master plan of creation still in operation. These stories seemed to be related to the processes that hold all life sciences together. Vasco has a good background in basic geology and botany; hence, the biology and geology groups planned joint field trips into southern and western Utah. Dr. Walter P. Cottam, then chairman of the Botany Department, was also a dynamic student of plant ecology at that time and still is a super teacher of Great Basin area problems.

Both the Tanner and Hansen families spent each summer for fifteen years at the Aspen Grove summer camp, and our children sort of grew up together. This camp life stimulated our family's thinking about nature's problems and the great out-of-doors. A trip with students to the skyline crest of Timpanogos was always an instructional climb, and Vasco Tanner was in the midst of it with all his heart and soul.

When his daughter, Carmella, toured Europe with a BYU student group, Vasco, by letter, reminded her of the many interesting places she was visiting and briefed her on the historical significance connected with those places.

Dr. Tanner was, and still is, meticulous and precise in all that he does. This serves as an object lesson for all of us who know him best. His enthusiasm is catching, and many students in many parts of the world are carrying on where he is leaving off.

Our families are widely scattered, and they in turn have their own new families, who, as a second generation, are privileged to know something of their heritage in this great mountain land on a wonderful spinning planet.

To Vasco and Annie and their children's children we say, "God bless."—George and Afton.

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A CATALOGUE OF THE FISH, AMPHIBIAN, AND REPTILE TYPES IN THE BRIGHAM YOUNG UNIVERSITY MUSEUM OF NATURAL HISTORY

Wilmer W. Tanner[1]

Since 1950 there has been a substantial increase in the number of type specimens deposited in the Brigham Young University Vertebrate Collection. These have come not only from recent descriptions of new species and subspecies described from the materials available in the collection but also from outside acquisitions.

This collection was begun in 1925 under the direction of Dr. Vasco M. Tanner, who at that time came to the University as head of the Department of Zoology and Entomology. Although Dr. Tanner is basically an entomologist, he understood the need for research collections and was therefore the initiator and moving force which has resulted in the establishment of research collections in several disciplines of zoology and entomology at the University.

The collection consists mainly of materials from Utah and the adjoining states; however, much material is available from other parts of the United States, the Far East, South Pacific, Mexico,[2] Central America,[2] and Africa.[2]

The types are listed phylogenetically with the citation of the original description following each species name. Each holotype with the original museum and tag number is listed. Paratypes now in the BYU collection are listed; if they originally bear the number of another museum, it is also indicated. Paratypes described from BYU materials will be indicated only in terms of the tag number of such specimens now in the collection. New names proposed by Vasco M. Tanner will show his name as V. Tanner, whereas those proposed by Wilmer W. Tanner will not include an initial.

The following abbreviations are used:

AMNH—American Museum of Natural History, New York City.
BYU—Brigham Young University, Provo, Utah.
CAS—California Academy of Sciences, San Francisco, California.
CNHM—Chicago Natural History Museum, Chicago, Illinois.
EHT-HMS—Edward H. Taylor and Hobart M. Smith Private Collection, University of Kansas and University of Illinois, respectively.
KU—University of Kansas, Lawrence, Kansas.
MMZ—Michigan Museum of Zoology, University of Michigan, Ann Arbor, Michigan.
MVZ—Museum of Vertebrate Zoology, University of California, Berkeley.

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[2]Some of the Mexican material is in the private collection of W. W. Tanner. It is included here because it is tagged with BYU museum numbers and is intended to be deposited at BYU in the future

RCT—Richard C. Taylor, private collection, University of Kansas (E. H. Taylor), Lawrence, Kansas.
SDSNH—San Diego Society of Natural History, San Diego, California.
UIMNH—University of Illinois Museum of Natural History, Urbana, Illinois.
USNM—United States National Museum, Washington, D.C.

Order Ostariophysi
Suborder Cyprinoidea
Family Catostomidae

Notolepidomyzon utahensis V. Tanner, 1932. Copeia 1932(3):135-6.
Holotype: BYU 1135, Santa Clara Creek, Veyo, Washington County, Utah. V. M. Tanner, collector.
Paratypes (9): BYU 1134, 1136, 1421, 2302, 2304, 2306, 2347-8, and 2349.

Notolepidomyzon intermedius V. Tanner, 1942. Great Basin Nat. 3(2):27-32.
Holotype: BYU 4252, White River, near the big spring between Lund and Preston, White Pine County, Nevada. G. L. Hendrix, collector.

Family Cyprinidae

Gila jordani V. Tanner, 1950. Great Basin Nat. 10(1-4):31-36.
Holotype: BYU 9959, Crystal Springs, Lincoln County, Nevada. V. M. Tanner, collector.
Paratypes (5): BYU 8980-1, 9084, 9958, and 9960.

Order Gymnophiona
Family Ichthyophiidae

Ichthyophis youngorum Taylor, 1960. Univ. Kansas Sci. Bull. 40: 89-91, figs. 23-27.
Holotype: EHT-HMS No. 35946, type locality, Doi Suthep, Chicag Mai, Thailand. E. H. Taylor, collector.
Paratype: BYU 14637, orig. No. EHT-HMS 35935.

Order Caudata
Family Plethodontidae

Thorius pulmonaris Taylor, 1940. Univ. Kansas Sci. Bull. 26:411-14.
Holotype: EHT-HMS 16684, type locality, Cerro San Felipe, about 12 km. N Oaxaca, Oaxaca, Mexico. E. H. Taylor, collector.
Paratype (1): BYU 13252, orig. No. EHT-HMS 16713, topotype.

Bolitoglossa marmorea Tanner and Brame, 1961. Great Basin Nat. 21(1 & 2): 23-26.
Holotype: BYU 17704, type locality, Crater of Volcan Baru, Chiriqui Province, Panama. V. J. Tipton, collector.
Paratypes (11): BYU 17700-3 and 17705-11 topotypes.

Pseudoeurycea smithi (Taylor), 1939. Univ. Kansas Sci. Bull. 25: 269-72.
HOLOTYPE: EHT-HMS 3966, type locality, Cerro de San Luis, 15 mi. NW Oaxaca, Oaxaca. E. H. Taylor, collector.
PARATYPE (1): BYU 13251, orig. No. EHT-HMS 15637.

Chiropterotriton arborea (Taylor), 1941. Herpetologica 2(3):62-65.
HOLOTYPE: EHT-HMS 16743, type locality, near Tianguistingo, Hidalgo, Mexico. E. H. Taylor, collector.
PARATYPE: BYU 13253, orig. No. EHT-HMS 16751.

Chiropterotriton bromeliacia Schmidt, 1936. Zool. Series Field Mus. Nat. Hist. 20(17):161-3.
HOLOTYPE: FMNH 21062, type locality, Volcan Tajumulco, at 8,000 ft. on trail above El Porvenir, San Marcos, Guatemala. K. P. Schmidt, collector.
PARATYPES (2): BYU 15583-4, orig. No. FMNH 20697.

Chiropterotriton abscondens Taylor, 1948. Proc. Biol. Soc. Washington 61:177-80.
HOLOTYPE: RCT 1414, type locality, Isla Bonita, 5,500 ft. Volcan Poas, Caribbean Drainage, Costa Rica. E. H. Taylor, collector.
PARATYPE (1): BYU 11767, orig. No. RCT 1410.

Family Bufonidae

Bufo nayaritensis Taylor, 1943. Univ. Kansas Sci. Bull. 29:349-351.
HOLOTYPE: EHT-HMS 397, type locality, Tepic Nayarit, Mexico. E. H. Taylor, collector.
PARATYPE (1): BYU 14638, orig. No. EHT-HMS 419.

Order Squamata

Suborder Sauria

Family Sphaerodactylidae

Sphaerodactylus decoratus granti Thomas and Schwartz, 1966. Brigham Young Univ. Sci. Bull. 7(4):10-11.
HOLOTYPE: BYU 17233, type locality, Banes Oriente Province, Cuba.
PARATYPES (110): BYU 17192-232, 17234-268, 22889-920 and two untagged specimens now BYU 36413-14.

Sphaerodactylus torrie spielmani Grant, 1958. Herpetologica 14(4): 225-27.
HOLOTYPE: UIMNH 44105, type locality, Guantanamo, Oriente Province, Cuba. Andrew Spielman, collector.
PARATYPES (2): BYU 17165-6.

Family Gekkonidae

Coleonyx variegatus utahensis Klauber, 1945. Trans. San Diego Soc. Nat. Hist. 10:171-176.
HOLOTYPE: SDSNH 35792, type locality, Watercress Spring, St.

George, Washington County, Utah. Ross Hardy, collector.
PARATYPES (2): BYU 36411 and 36412, orig. No. Dixie Junior College 788 and 826.

Phyllodactylus tuberculosus saxatilis Dixon, 1964. New Mexico State Univ. Sci. Bull. 64-1:31-36.
HOLOTYPE: KU 67514, type locality, 8 mi. NE Villa Union, Sinaloa, Mexico. J. R. Dixon, collector.
PARATYPES (5): BYU 13910-14.

Phyllodactylus muralis muralis Taylor, 1940. Univ. Kansas Sci. Bull. 26:543-47.
HOLOTYPE: CNHM 100090, orig. No. EHT-HMS 10902, type locality, near Totolapan, Oaxaca, Mexico. H. M. Smith, collector.
PARATYPE (1): BYH 16551, orig. No. EHT-HMS 10925.

Pseudogekko shebae Brown and V. Tanner, 1948. Great Basin Nat. 9(3-4):41-5.
HOLOTYPE: BYU 7002, type locality, lower Lunga River area, Guadalcanal Island. D E. Beck, collector.

Family Iguanidae

Brachylophus brevicephalus Avery and Tanner, 1970. Great Basin Nat. 30(3):166-172.
HOLOTYPE: BYU 32662, type locality, Nukolofa, Tougatabu Island, Tongan Islands. Bert Nixon, collector.
PARATYPES (8): BYU 23743, 31094-6, 31102, 31955, 32661, and 32663.

Crotaphytus collaris auriceps Fitch and Tanner, 1951. Trans. Kansas Acad. Sci. 54:548-59.
HOLOTYPE: KU 29934, type locality, 3½ mi. NNE Dewey, West side of Colorado River, Grand County, Utah. H. S. Fitch, collector.
PARATYPES (10): BYU 476, 551, 1461, 1464-5, 1623, 1625-6, and 10338-9.

Crotaphytus wislizeni punctatus Tanner and Banta, 1963. Great Basin Nat. 23(3-4):129-148.
HOLOTYPE: BYU 20928, type locality, Yellow Cat District, approx. 10 mi. S, U. S. Highway 50-B, Grand County, Utah. W. W. Tanner, collector.
PARATYPES (107): BYU 114, 122, 482, 924-8, 8396-7, 9040-1, 11329-30, 11271, 11325, 11347-8, 11363, 11378-81, 11742, 12008, 12186, 12187, 12554, 12558, 12614-17, 12685, 12846, 12853, 12857, 12859-600, 12873, 14912, 14913, 14981, 16497, 16751, 16797-8, 20610, 20920-30, 20931, and 20934-9.

Sauromalus obesus multiforaminatus Tanner and Avery, 1964. Herpetologica 20(1):38-42.
HOLOTYPE: BYU 11376, type locality, North Wash., 11 mi. NW Hite, Garfield County, Utah. W. W. Tanner, collector.

PARATYPES (20): BYU 11734-5, 12710, 14879-87, 11259, 2858, 16615, 21507, and 29994.

Uma paraphygas Williams, Chrapliwy and Smith, 1959. Trans. Kansas Acad. Sci. 62(2):166-72.
HOLOTYPE: UIMNH 42889, type locality, sand dunes, 0.7 mi. E Carrillo, Chihuahua, Mexico. K. L. Williams and P. S. Chrapliwy, collectors.
PARATYPE (1): BYU 16550, orig. No. UIMNH 42888.

Sceloporus merriami australis Williams, Smith and Chrapliwy, 1960. Trans. Illinois State Acad. Sci. 53(1-2):36-45.
HOLOTYPE: UIMNH 43319, type locality, 15.6 mi. E Cuatro Crenegas, Coahuila, Mexico. P. S. Chrapliwy and K. L. Williams, collectors.
PARATYPE (1): BYU 16552, orig. No. UIMNH 43318.

Sceloporus spinosus apicalis Smith and Smith, 1951. Proc. Biol. Soc. Washington 64:101-4.
HOLOTYPE: UIMNH 8864, type locality, 10 mi. SW Miahuallan, Oaxaca, Mexico. W. L. Burger, collector.
PARATYPE (1): BYU 16553, orig. No. UIMNH 8865.

Sceloporus poinsetti macrolepis Smith and Chrapliwy, 1958. Herpetologica 13(4):267-71.
HOLOTYPE: UIMNH 35455, type locality, El Salto, Durango. Barden and I. L. Firschein, collectors.
PARATYPES (5): BYU 13855-8 and 13860.

Sceloporus clarki uriquensis Tanner and Robison, 1959. Great Basin Nat. 19(4):75-9.
HOLOTYPE: BYU 14311, type locality, Urique, Chihuahua, Mexico. W. W. Tanner and W. G. Robison, collectors.
PARATYPES (2): BYU 14310 and 14312.

Sceloporus nelsoni barrancorum Tanner and Robison, 1959 (1960). Great Basin Nat. 19(4):79-82; also see Herpetologica 16:114.
HOLOTYPE: BYU 14316, type locality, Urique Chihuahua, Mexico. W. W. Tanner and W. G. Robison, collectors.
PARATYPES (8): BYU 14315, 14317-8, 14320, and 14322-5.

Sceloporus magister cephaloflavus Tanner, 1955. Great Basin Nat. 15(1-4):32-4.
HOLOTYPE: BYU 11270, type locality, approx. 15 mi. NW Hole-in-the-Rock, Kane County, Utah. D E. Beck, collector.
PARATYPES (84): BYU 115, 119, 123, 531, 901-5, 912-16, 929-37, 1780-1, 4183-4, 9769, 11263-4, 11392-8, 11390, 11399-400, 11903, 12007, 12445, 12620, 12680-3, 12712-4, 12845, 12885-6, 12947, 13151, 13153-66, 13174, 13143-4, 13067, 13167-72, 2126-7, 2134-5.

Uta stansburiana uniformis Pack and Tanner, 1970. Great Basin Nat. 30(2):71-90.
HOLOTYPE: BYU 10035, type locality, Split Mt., West side of Colorado River, Uintah County, Utah. W. W. Tanner, collector.

PARATYPES (24): BYU 5524-5, 5527, 5529, 8398, 10036-7, 13030-2, 20179, 21231-2, 21235, 21240-1, 21245, 22985-7, and 32328-31.

Family Helodermatidae

Heloderma suspectum cinctum Bogert and Martin Del Campo, 1956. American Mus. Nat. Hist. 109(1):46-56.
HOLOTYPE: AMNH 7456, type locality, Las Vegas, Clark County, Nevada. W. H. Rogers, collector.
PARATYPES (2): BYU 10403-4.

Family Xantusidae

Xantusia vigilis utahensis Tanner, 1957. Herpetologica 13:5-11.
HOLOTYPE: BYU 11733, type locality, approx. 20 mi. NW Hite, North Wash, Garfield County, Utah. W. W. Tanner and W. L. Tanner, collectors.
PARATYPES (7): BYU 11731-32, 12644-7, and 13238.

Family Teidae

Cnemidophorus sacki neomexicana Lowe and Zweifel, 1952. Bull. Chicago Acad. Sci. 9(13):229-47.
HOLOTYPE: MVZ 55897, type locality, McDonald Ranch Headquarters, 8.7 mi. W and 22.8 mi. S New Bingham Post Office, Socorro County, New Mexico. C. H. Lowe, Jr., collector.
PARATYPE (1): BYU 13250, orig. No. UIMNH 32561.

Family Scincidae

Ernoia caernleocauda reimschiisseli V. Tanner, 1950. Great Basin Nat. 10(1-4):1-30.
HOLOTYPE: BYU 7416, type locality, near Pitu airfield, Morotai Island, South Pacific. E. F. Reimschiissel, collector.
PARATYPES (93): BYU 7312, 7332-3, 7335-8, 7409-11, 7416-23, 7491-9, 7500-7, 7509-25, 7527, 7550-3, 7556, 7567-70, 7572-3, 7681-2, 7684, 7686-7, 7698-7711, 7725, and 7880.

According to the account in the original description 80 specimens were designated as paratypes. This figure should have been 93, as indicated above.

Eumeces multilineatus Tanner, 1957. Great Basin Nat. 17(3-4): 111-17.
HOLOTYPE: BYU 13798, type locality, 3 mi. N Colonia Chuhuichupa, Chihuahua, Mexico. W. W. Tanner and W. G. Robison, collectors.
PARATYPE (1): BYU 11984.

Eumeces skiltonianus utahensis Tanner, 1957. Great Basin Nat. 17(3-4):59-72.
HOLOTYPE: BYU 6945, type locality, edge of Cedar Valley, approx. ½ mi. W of Chimney Rock, Utah County, Utah. W. W. Tanner, collector.

Paratypes (67): BYU 536-7, 1795-6, 2099, 2217-39, 2292-3, 2780, 2849-50, 6946, 9067, 10402, 11969-70, 12651-9, and 13133-51.

Suborder Serpentes

Family Typhlopidae

Typhlops becki V. Tanner, 1948. Great Basin Nat. 9(1-2):1-20.
Holotype: BYU 7448, type locality, Tenaru River, NE Guadalcanal, Solomon Islands. D E. Beck, collector.

Family Leptolyphlopidae

Leptotyphlops humilis utahensis V. Tanner, 1938. Proc. Utah Acad. Sci., Arts, and Letters 15:149-150.
Holotype: BYU 662, type locality, St. George, Washington County, Utah. V. M. Tanner and A. Paxman, collectors.
Paratypes (5): BYU 88, 607, 1689, 1831, and 1842.

Family Colubridae

Thamnoplis melanogaster chihuahuaensis Tanner, 1959. Herpetologica 15:166-72.
Holotype: BYU 14197, type locality, Rio Bavispe below Tres Rios, near Sonora-Chihuahua line. W. W. Tanner and W. G. Robison, Jr., collectors.
Paratypes (14): BYU 13371, 13373, 13451, 13493, 13496, 13505, 14198-02, and 14208-10.

Thamnophis eques virgatenuis Conant, 1963. Copeia 1963(3):473-99.
Holotype: AMNH 89792, type locality, 6 mi. W El Salto, Durango, Mexico. W. Auffenberg *et al.*, collectors.
Paratypes (34): BYU 13896-7, 13919-20, 14377-80, 14482, 14497-500, 15641-3, 15737-41, 17028-9, 17074-5, and 17087-90.

Salvadora hexalepis mojavensis Bogert, 1945. American Mus. Novitates 1285:1-14.
Holotype: AMNH 63000, type locality, Deadman Point, 11.5 mi. SE Victorville, S end Granite Mts., San Bernardino Co., California.
Paratypes (3): BYU 1097, 1499, and 2880.

Lampropeltis doliata taylori Tanner and Loomis, 1957. Trans. Kansas Acad. Sci. 60(1):12-42.
Holotype: BYU 10533, type locality, 2 mi. N Alpine, Utah County, Utah. W. W. Tanner, collector.

Paratypes (24): 163, 334, 336-7, 389, 398, 520, 1505, 2718, 2929-30, 2933, 6023, 8922-3, 11100-4, 11114, and 11116-7.

Lampropeltis pyromelana woodini Tanner, 1953. Great Basin Nat. 13(1-2):47-66.
Holotype: MMZ 69653, type locality, Carr Canyon, Huachuca

Mts., Cochise County, Arizona.
PARATYPE (1): BYU 11293.

Lampropeltis pyromelana infralabialis Tanner, 1953. Great Basin Nat. 13:47-66.
HOLOTYPE: BYU 10340, type locality, Mountains 5 mi. E Beaver, Beaver County, Utah. R. Liechty, collector.
PARATYPES (5): BYU 304, 322, 634, 8634, and 11289.

Conopsis nasus labialis Tanner, 1961. Herpetologica 17:13-18.
HOLOTYPE: BYU 16858, type locality, 25 mi. SE Creel, Chihuahua, Mexico. W. W. Tanner and W. G. Robison, Jr., collectors.
PARATYPES (13): BYU 14295-8, 16952, 16854-7, and 16859-62.

Hypsiglena torquata nuchalata Tanner, 1943. Great Basin Nat. 4(1-2):49-54.
HOLOTYPE: BYU 3008, type locality, Lemon Cave, Tulare County, California. Stanley A. Mulaik, collector.

Hypsiglena torquata deserticola Tanner, 1946 (1944). Great Basin Nat. 5(3-4):59-63.
HOLOTYPE: BYU 2836, type locality, 3.6 mi. W Chimney Rock Pass, Utah County, Utah. W. W. Tanner, collector.
PARATYPES (10): BYU 640, 2026-8, 2196, 2709, 3014, 3938, 7937, and 8014.

Hypsiglena torquata loreala Tanner, 1946 (1944). Great Basin Nat. 5(3-4):63-5.
HOLOTYPE: BYU 2829, type locality, West edge Castle Dale, Emery County, Utah. V. M. Tanner, collector.
PARATYPE (1): BYU 2192.

Hypsiglena torquata catalinae Tanner, 1966. Trans. San Diego Soc. Nat. Hist. 14(15):189-96.
HOLOTYPE: SDSNH 44680, type locality, Santa Catalina Island, Gulf of Calif., Baja Calif., Mexico. G. E. Lindsay, collector.
PARATYPE (1): BYU 23556, orig. No. UCM 25952.

Tantilla phrenitica Smith, 1942. Zoologica 27(7):33-42.
HOLOTYPE: USNM 110381, type locality, Cuautlapan, Veracruz, Mexico. E. H. Taylor, collector.
PARATYPE (1): BYU 13254, orig. No. EHT-HMS 23570.

Tantilla planiceps utahensis Blanchard, 1938. Field Mus. Nat. Hist. Zool. Ser. 20:372-3.
HOLOTYPE: CAS 55214, type locality, St. George, Washington County, Utah. V. M. Tanner, collector.
PARATYPES (5): BYU 310 (old Ser. 2274), 1240, 1518, 1553, and 1571.

Crotalus lannomi Tanner, 1966. Herpetologica 22(4):298-302.
HOLOTYPE: BYU 23800, type locality, 1.8 mi. W pass Puerto Los Mazos or 22 mi. W (by road) Rio Tuxcacuesco, Highway 80, Jalisco, Mexico. J. R. Lannom, Jr., collector.

TANNEROCORIS NEW GENUS, AND NEW SPECIES OF MIRIDAE (HEMIPTERA) FROM THE WESTERN UNITED STATES

Harry H. Knight[1]

Tannerocoris, n. gen.

The claws and arolia are very similar to those of *Nevadocoris* Kngt. which places the genus in subfamily Phylinae. In my key to the genera of Phylinae (1968) this form runs in the couplet with *Oncotylus* Fieb. and *Nevadocoris* Kngt. *Tannerocoris* differs from *Nevadocoris* by the rows of rather large black spots on the femora; from *Oncotylus* it differs by the more slender antennae, and by the wider head and broader vertex.

Description.— Second antennal segment slender, its thickness only half that of first segment. Dorsal surface clothed with appressed, silvery, sericeous pubescence, and sparsely intermixed with suberect pubescent hairs. Legs only with black spots; tibial spines with a small black spot at base of each. Type of genus: *Tannerocoris sarcobati*, new species.

This genus is named for Dr. Vasco M. Tanner who has served as editor of the *Great Basin Naturalist* for the past thirty years. For several decades Dr. Tanner has been influential in the growth and development of public recreation facilities, of conservation of natural resources, of civic affairs, and of graduate education in the biological sciences in Utah and neighboring states. He is also recognized nationally and internationally as an outstanding entomologist, particularly as a great authority in knowledge of the great order Coleoptera.

I take great pleasure in naming this new genus for Dr. Tanner as a memorial to him among the perpetual generic name books and catalogs of zoological science.

Tannerocoris sarcobati, n. sp.

Male.— Length 4.2 mm, width 1.36 mm. Head: width .95 mm, vertex .48 mm; pale, clypeus black, frons black each side of pale median line; vertex pale but with a rounded black spot each side and touching eye margin; lorum with black but margins narrowly pale; eyes brown. Rostrum, length 1.22 mm, reaching to apex of middle coxae, pale yellowish. Antennae: segment I, length .30 mm, black; II, 1.32 mm, cylindrical, thickness .07 mm, yellowish, basal half more or less infuscated, pubescence very short and inconspicuous; III, .85 mm, dusky yellow; IV, .37 mm, pale fuscous. Pronotum, length .64 mm, width at base 1.19 mm; lateral margins of disk rounded, disk pale, basal half more or less infuscated, calli black; propleura fuscous to black, ventral margin pallid. Mesonotum ex-

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posed, pale to dusky, middle third fuscous. Scutellum nearly flat, basal half slightly convex, pale to fuscous.

Dorsal surface clothed with appressed, silvery, sericeous pubescence, intermixed with short, recumbent, pallid to brownish, simple pubescent hairs. Hemelytra pallid, shaded with fuscous; cuneus and embolium more pallid; membrane pale fuscous, veins pallid. Ventral surface fuscous to black, clothed with moderately abundant, appressed, silvery, sericeous pubescence. Legs pallid, tinted with pale yellowish; hind femora with a row of moderately large fuscous spots on dorsal aspect, a second row of slightly smaller fuscous spots along middle of anterior aspect, ventral margin with five or six smaller fuscous spots; tibiae pale yellowish, spines black, each with a blackish spot at base; tarsi pale yellowish to dusky, claws black. Genital segment typical of Phylinae.

Female.— Length 4.1 mm, width 1.6 mm; embolar margins moderately arcuate. Head: width .98 mm, vertex .54 mm; pallid, black areas similar to male, but black patch each side of frons less extensive. Rostrum reaching to apex of middle coxae, pallid. Antennae: segment I, length .31 mm, thickness .07 mm, pale to dusky; II, 1.26 mm, cylindrical, slender, thickness just half that of segment I, pale to dusky yellow, pubescence short and recumbent; III, .85 mm, dusky yellow; IV, .34 mm, dusky. Pronotum, length .62 mm, width at base 1.29 mm; disk only slightly convex; disk pallid, calli flat, black, propleura with fuscous area on middle. Mesonotum white, small fuscous area on middle; scutellum pallid. Hemelytra pallid, subtranslucent, not infuscated; membrane slightly dusky, veins white. Pubescence very similar to that of the male. Ventral surface pallid to white. Legs pallid, black spots very similar to those in the male. The venter opaque white.

Holotype.— ♂ June 19, 1932. Yakima, Washington (A. R. Rolfs). Allotype: same data as for type. Paratype: 2♂, 10♀ taken with the holotype on the host, *Sarcobatus vermiculatus*. 6♂, 2♀ June 5, 1930, Yakima, Washington (A. R. Rolfs). Colorado: 1♀ June 15, 1904 (E. S. G. Titus), "on sugar beets." 2♀ July 19, Durango (Russian). Idaho: 2♂ March 31, 1969, Black Pine, Oneida County; ♀ June 13, 1969, Holbrook, Oneida County (G. F. Knowlton). 2♂ May 31, 1969, Black Pine, Oneida County; Utah: 1♀ May 31, 1969, Curlew Junction, Box Elder County (G. F. Knowlton). South Dakota: 2♀ June 27, 1937, Martin (H. C. Severin).

Europiella knowltoni, n. sp.

Runs in my key to the species of *Europiella* (1968) to the couplet with *nigrofemoratus* Kngt., but differs from it by the pale and unspotted tibiae.

Male.— Length 4.8 mm, width 1.5 mm. Head: width .95 mm, vertex .52 mm; black. Rostrum, length 1.02 mm, reaching upon middle coxae, pallid to fuscous. Antennae: segment I, length .27 mm, width .11 mm, black; II, 1.36 mm, pale yellowish to light fuscous, thickness only slightly less than segment I; III, .85 mm, yellowish;

IV, .37 mm, pale fuscous. Pronotum, length .51 mm, width at base 1.21 mm; brownish black. Mesoscutum exposed, and along with scutellum, brownish black. Hemelytra fuscous brown, subtranslucent, clavus and cuneus more brownish black; membrane fuscous, veins somewhat darker.

Dorsal surface clothed with moderately thick, recumbent, brownish simple pubescence, and intermixed with appressed, silvery, sericeous pubescence. Ventral surface brownish black. Legs brownish black, but tibiae pale yellowish to dusky, spines black but without spots at base, tarsi dusky yellow. Genital segment and claspers very similar to generic type.

Female.— Length 3.6 mm, width 1.6 mm. Head: width 1.02 mm, vertex .56 mm, brownish black. Rostrum, length 1.19 mm, reaching to apex of middle coxae, brownish black. Antennae: segment I, length .27 mm, thickness .10 mm, black; II, 1.15 mm, cylindrical, thickness just two-thirds that of segment I, pallid to pale yellowish, apical one-fifth fuscous brown; III, .54 mm, yellowish brown; IV, .27 mm, dusky brown. Pronotum, length .54 mm, width at base 1.22 mm, brownish black. Dorsal surface brownish black; embolium and basal half of corium paler brown. Pubescence very similar to male. Ventral surface brownish black, also bearing sericeous, silvery pubescence. Legs very similar to the male.

Holotype.— ♂ May 31, 1969, Black Pines, Oneida County, Idaho (G. F. Knowlton); Knight Collection. Allotype: ♀ June 6, 1969, Curlew Reservoir, Oneida County, Idaho (G. F. Knowlton). Paratype: 5 ♀ taken with the holotype.

This species is named for the collector, Dr. George F. Knowlton, long-time member of the Experiment Station staff at Utah State University, who is very active in collecting and making known the insect species of Utah.

Europiella multipunctipes, n. sp.

In my key to the species of *Europiella* (1968), this species runs in the couplet with *sparsa* Van Duzee from which it may be separated by the numerous small fuscous dots on the femora; ventral surface of body never with black.

Male.— Length 3.2 mm, width 1.3 mm. Head: width .88 mm, vertex .47 mm, pale yellowish, never with black. Rostrum, length .95 mm, reaching upon apex of middle coxae, pale yellowish. Antennae: segment I, length .20 mm, pale; II, .816 mm, pale yellowish, with minute pale pubescence; III, .58 mm, dusky; IV, .34 mm, dusky. Pronotum, length .47 mm, width at base 1.08 mm; pale yellowish. Mesonotum exposed, and with scutellum pale yellowish. Hemelytra pallid to yellowish, in part subtranslucent; cuneus color similar to corium; membrane pallid to clear, veins white.

Dorsal surface clothed with appressed, silvery, sericeous pubescence, intermixed with recumbent, dusky to fuscous simple pubescence; color varies with angle of light. Ventral surface pallid to yellowish, never with fuscous. Legs pallid, femora with numerous

small fuscous dots, rows not well established; tibiae pallid, spines pale to brownish, a fuscous dot at base of each.

Female.— Length 3.1 mm, width 1.5 mm. Head: width .92 mm, vertex .54 mm; pallid to yellowish. Rostrum, reaching to apex of middle coxae. Antennae: segment I, length .17 mm, pallid; II, .81 mm, pale yellowish; III, .51 mm, pale; IV, .34 mm. Pronotum, length .51 mm, width at base 1.12 mm. Dorsal surface pallid; pubescence very similar to that of the male. Ventral surface pallid. Legs pallid, femora marked with fuscous dots similar to the male.

Holotype.— ♂ July 12, 1965, Elko, Nevada (H. H. Knight); Knight Collection. Allotype: ♀ same data as the type. Paratype: 2♂, 10♀ taken with the types. All specimens were swept from a shrub I thought must be an *Atriplex*.

Europiella basicornis, n. sp.

In my key to the species of *Europiella* (1968)this species runs to couplet 11, but differs from both *stigmosa* (Uhl.) and *angulatus* (Uhl.). Legs pallid but hind femora with numerous fuscous microdots; second antennal segment pallid, black at base; segment I black.

Male.— Length 3.0 mm, width 1.3 mm. Head: width .75 mm, vertex .44 mm; pallid. Rostrum, length .95 mm, just reaching upon apex of middle coxae, pallid, apical segment black. Antennae: segment I, length .20 mm, black, apex narrowly pallid; II, .75 mm, pallid to yellowish, with black band at base; III, .58 mm, pale to dusky; IV, .37 mm, dusky. Pronotum, length .40 mm, width at base .64 mm; pallid. Mesonotum and scutellum pallid. Hemelytra uniformly pallid to milky white, cuneus included; membrane clear, veins opaque white. Dorsal surface clothed with pallid, simple, suberect pubescent hairs, intermixed with more appressed, silvery, sericeous pubescence. Ventral surface pallid to fuscous, sternum and venter more fuscous. Legs pallid, femora with numerous micro to small fuscous dots, more abundant on hind femora; tibial spines black, with a prominent black spot at base of each; base of tibia, or knee, with a large prominent black spot; tarsi pale to fuscous.

Holotype.— ♂ July 13, 1965, Coalville, Utah (H. H. Knight); Knight Collection.

Europiella monticola, n. sp.

In my key to the species of *Europiella* (1968) this species runs in the couplet with *concinna* Reut., but differs in the pallid color; hemelytra pallid, but with membrane dark fuscous on apical half.

Male.— Length 4.1 mm, width 1.4 mm. Head: width .88 mm, vertex .51 mm; pale yellowish. Rostrum, length .98 mm, reaching upon apex of hind coxae, pallid, apical segments three and four, black. Antennae: segment I, length .24 mm, dark fuscous to black; II, 1.63 mm, cylindrical, fuscous; III, .68 mm, fuscous; IV, .40 mm, fuscous. Pronotum, length .54 mm, width at base 1.32 mm, pallid to dusky. Mesonotum pallid, slightly fuscous on middle. Scutellum pallid. Hemelytra pallid, slightly subtranslucent; membrane dark

fuscous, areoles somewhat paler, veins opaque white. Dorsal surface clothed with pallid to yellowish, simple recumbent pubescence, intermixed with a limited amount of more appressed, sericeous, golden yellow pubescence. Ventral surface pallid, but genital segment fuscous. Legs pallid, femora with a dorsal row of indistinct, shattered fuscous spots, ventral margin with five or six definite fuscous dots, also a row of indistinct fuscous dots along middle of anterior aspect; tibial spines black and with a black spot at base of each; tarsi fuscous.

Female.— Length 3.4 mm, width 1.4 mm. Head: width .92 mm, vertex .57 mm; pallid. Rostrum, length .81 mm, reaching to apex of middle coxae. Antennae: segment I, length .20 mm, yellowish; II, .74 mm, yellowish to dusky fuscous; III, .51 mm, fuscous; IV, .34 mm, fuscous. Dorsal surface color and pubescence very similar to that of the male. Ventral surface pallid. Legs pallid, spotting on femora and tibiae similar to that of male.

Holotype.— ♂ July 11, 1964, near Rabbit Ears Pass, alt. 9680 ft., Colorado (H. H. Knight); Knight Collection. Allotype: ♀ taken with the type. Paratype: 1♂, 1♀ taken with the types. Specimens were swept from a small shrub resembling *Artemesia* that grew in a depressed spot along the highway.

Literature Cited

Knight, Harry H. 1968. Taxonomic review: Miridae of the Nevada Test Site and the western United States. Brigham Young Univ. Sci. Bull., Biol. Ser. 9(3):1-282, 318 figs.

NEW OR LITTLE-KNOWN TIPULIDAE FROM MIDDLE AMERICA (DIPTERA). I

Charles P. Alexander[1]

I am honored in being able to provide a paper in the present issue of the *Great Basin Naturalist* which commemorates the work of Professor Vasco M. Tanner during the past thirty years. As founder and leader in the work of the *Naturalist* Professor Tanner has the thanks and appreciation of many botanists and zoologists who have been interested in the life of the American West. Since its founding, Professor Tanner has published many of his own studies in the *Naturalist*, covering a surprising range of subjects, including the herpetology of Eastern Asia, many of the Pacific islands, and a number of contributions to insect ecology and biology. His principal work in insect taxonomy has been with the Coleoptera, primarily weevils; however, further work includes papers on the Cicindelidae and Tenebrionidae. A further indication of the breadth of his interests is his account of the life of Linnaeus at the Linnean Bicentennial in 1958.

I became associated with the *Naturalist* shortly after its founding, between 1943 and 1968, publishing therein a total of fourteen papers on the Diptera. The initial series of four papers was entitled "Undescribed species of Western Nearctic Tipulidae (Diptera)," appearing in volume 4, 1943. There were three additional parts under this title, the fourth and last in volume 21, 1961. At that time it was felt advisable to widen the scope of this series and the title was changed to "Undescribed species of Nearctic Tipulidae" and so involved the entire region. Under this title a total of nine papers have appeared, the first in volume 21, 1961, the latest in volume 28, 1968. In addition to the above, one other article has been published, "A new net-winged midge from Idaho (Blepharoceridae, Diptera)," in volume 25, 1965. It may be stated that in the 1943 paper cited plans were laid for a detailed study of the crane flies of the Rocky Mountain and Pacific Coast states and provinces from Mexico to Alaska. It was believed that there might be in excess of 1000 species of these flies in this area, and it can be stated that this figure now has been exceeded.

Mrs. Alexander and I visited Provo once during June 1949. We greatly appreciated the beautiful campus and buildings of Brigham Young University and the opportunity of meeting certain of the faculty and students, including, in addition to Professor Tanner, his brother Wilmer W. Tanner, in ecology; Bertrand F. Harrison, in botany; C. Lynn Hayward, in zoology; and others. Following this brief visit to the campus on June 20 we spent the following two days at the Brigham Young University biological station near Aspen

[1]Amherst, Massachusetts.

Grove, below Mount Timpanogos in the beautiful Wasatch Mountains. We met several faculty members and students at the station and appreciated a visit from Dr. George F. Edmunds, Jr., leading student of the Mayflies of Utah, who subsequently completed his Doctor of Philosophy thesis at the University of Massachusetts on that subject.

Again, may I express my deepest thanks and appreciation to Professor Tanner for a long and most profitable association and for his encouragement in entomological work. Mrs. Alexander and I join a host of other friends and associates in wishing Vasco and his wife many years of health and continued work on his favorite insect groups.

In the present paper I am discussing certain crane flies from various republics in Middle America, from Mexico to Panama. For these I am indebted to four of my former students at the University of Massachusetts: Dr. Thomas H. Farr of the Institute of Jamaica; Dr. Gordon Field of the University of Rhode Island; Dr. Oliver S. Flint, Jr., of the Smithsonian Institution, Washington; and Dr. Marion Estelle Smith of the University of Massachusetts. Their thoughtfulness and consideration in collecting these specimens are much appreciated. It should be noted that one of the included novelties is a very distinct species that is dedicated to Professor Tanner. Types of all the species are preserved in the Alexander Collection.

Tipulinae

Zelandotipula serratimargo, n.sp.

General coloration of thoracic dorsum pale brown, inconspicuously patterned, including four praescutal stripes; antennae uniformly pale yellow; thoracic pleura above broadly light yellow, with a more ventral brown stripe; femora yellow, tips brown, remainder of legs chiefly dark brown; wings pale brown, restrictedly variegated by darker areas, without a spot in cell *M*, veins behind *R* glabrous; male hypopygium with outer dististyle pale, broadly flattened, more expanded outwardly, the margin of outer half with coarse irregular teeth; lobes of ninth tergite very low, nearly transverse, margins with abundant setae, the more lateral ones shorter and more spinoid.

Male.— Length about 18 mm; wing 19 mm; antenna over 4.5 mm.

Frontal prolongation of head obscure yellow above, pale brown on sides, nasus very long, slightly decurved; palpi with proximal three segments dark brown, terminal segment obscure brownish yellow, apex slightly darker. Antennae (outer segments broken) light yellow; flagellar segments cylindrical, verticils very short. Head yellow above, sides of vertex brown, more widened behind.

Pronotum light yellow, narrowly dark brown medially and on sides. Mesonotal praescutum light brown, the very restricted ground paler than the four discal stripes, the latter broadly margined by slightly darker brown; scutum almost uniformly obscure brownish

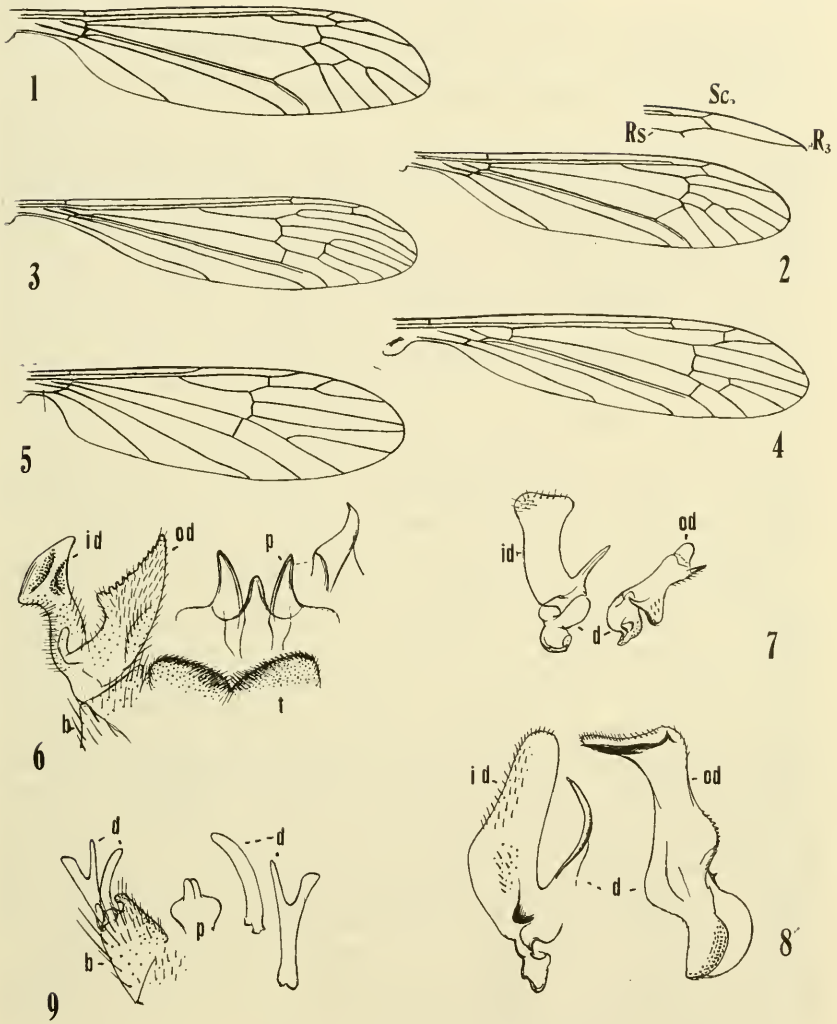
yellow, the suture clearer yellow; scutellum brownish yellow with sparse yellow setae; mediotergite brownish yellow, with sparse weak setae, pleurotergite pale brown posteriorly, ventral half yellowed. Pleura dorsally broadly light yellow, including the dorsopleural membrane, becoming more diffuse behind, reaching the abdomen; more ventrally with a brown longitudinal stripe extending from the cervical region across the pronotal scutum to the pleurotergite, paler and more diffuse behind; ventral pleura chiefly light yellow, sternopleurite vaguely lined with very pale brown. Halteres with stem obscure yellow, knob weakly more darkened, apex obscure yellow. Legs long; fore coxae weakly brownish yellow, remaining coxae and all trochanters yellow; femora yellow, tips brown, remainder of legs dark brown, bases of tibiae narrowly pale; claws with a strong tooth before midlength. Wings chiefly pale brown, prearcular and costal fields, the stigma, basal half of outer radial field and cell *1st* M_2 slightly darker brown; small and very inconspicuous still darker brown marks at origin of *Rs* and posterior end of *m-cu;* restricted whitened obliterative areas cephalad and basad of stigma; no darkening in cell M; extreme posterior wing border in medial and cubital cells slightly darkened; a whitened marginal dash in cell *1st A* before vein *2nd A;* veins brown, whitened in the obliterative areas at cord. Longitudinal veins behind *R* glabrous. Venation: Free tip of Sc_2 stout, longer than vein R_1 beyond it; vein R_3 beyond midlength subangular; petiole of cell M_1 and *m* subequal; *m-cu* shortly before fork of M_{3+4}.

Abdominal tergites light brown, obscure yellow laterally, posterior borders light brown, sternites more uniformly yellowed; hypopygium yellowed, including the appendages. Male hypopygium (Fig. 6) with ninth tergite, *t*, with lobes very low, their margins almost transverse, with numerous setae that are directed mesad, the outer ones shorter and stouter, slightly spinoid, inner setae longer and more delicate. Outer dististyle (shown at right in figure, as mounted on slide), *od*, broadly flattened, more expanded outwardly, outer half with margin oblique, coarsely and irregularly toothed, as shown; inner style, *id*, with the blackened spinoid setae or pegs arranged in two separate groups, the outer one with about 60 pegs, somewhat fewer in the inner or lower group, including a marginal series on a low elevated flange, base of style with abundant but inconspicuous long yellow setae. Phallosome, *p*, with apophyses longer than the aedeagus, appearing as short horns.

Habitat.— Guatemala.

Holotype.— ♂, Panajachel, Lake Atitlan, July 24-27, 1966 (M. E. Smith); in vegetation in pool at foot of waterfall, several hundred feet above lake along highway.

The present fly in general appearance is most similar to species such as *Zelandotipula diducta* (Alexander), Ecuador; *Z. flavicornis* (Alexander), Venezuela; *Z. flavogenualis* (Alexander), Peru; *Z. lassula* (Alexander), Ecuador, and *Z. tuberculifera* (Alexander), Peru. All of these differ among themselves in details of coloration



Explanation of Figures

Fig. 1. *Tipula* (*Bellardina*) *flinti*, n.sp.; venation.
Fig. 2. *Tipula* (*Eumicrotipula*) *estella*, n.sp.; venation.
Fig. 3. *Austrolimnophila* (*Austrolimnophila*) *subsessilis*, n.sp.; venation.
Fig. 4. *Shannonomyia semireducta*, n.sp.; venation.
Fig. 5. *Cheilotrichia* (*Empeda*) *tanneri*, n.sp.; venation.
Fig. 6. *Zelandotipula serratimargo*, n.sp.; male hypopygium.
Fig. 7. *Tipula* (*Bellardina*) *flinti*, n.sp.; male hypopygium.
Fig. 8. *Tipula* (*Bellardina*) *praelauta* Alexander; male hypopygium.
Fig. 9. *Cheilotrichia* (*Empeda*) *tanneri*, n.sp.; male hypopygium.

(Explanation of figures: Venation: *Sc*, Subcosta; *R*, Radius. Male hypopygium: *b*, basistyle; *d*, dististyle; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome: *t*, ninth tergite).

of the body and wings and especially in hypopygial structure, including the tergite, both dististyles, and the phallosome.

Tipula (Bellardina) flinti, n.sp.

Size large (wing of male over 18 mm); mesonotal praescutum light brown, disk with four blue-gray stripes; claws of male simple; wings chiefly pale yellow, vein *Cu* narrowly seamed with brown; male hypopygium with outer dististyle short and broad, the outer lateral spine short and spikelike; inner style widened at apex, appendage at base of blade a short straight point.

Male.— Length about 19 mm; wing 18.5 mm; antenna about 3.8 mm.

Frontal prolongation of head obscure yellow, including nasus; mouthparts dark brown; palpi with basal segment obscure yellow, intermediate segments brown, the terminal one black. Antennae with proximal three segments yellow, succeeding two or three brownish black basally, apices narrowly more yellowed, outer segments uniformly black; basal enlargements of flagellar segments small, verticils somewhat shorter than the segments. Head obscure yellow, vertex heavily white pruinose; vertical tubercle small, simple.

Pronotum light brown, sides more yellow pollinose. Mesonotal praescutum with lateral and humeral regions light brown, disk chiefly covered by four blue-gray stripes, the intermediate pair nearly contiguous in front, narrowed and divergent behind, the enclosed central space light gray; scutal lobes light gray, each with two darker gray areas, central region brownish yellow; posterior sclerites of notum brownish yellow. Pleura chiefly brownish yellow, ventral sternopleurite gray, anepisternum very slightly darkened, propleura brown. Halteres with stem yellow, knob dark brown. Legs with coxae yellow, very faintly whitened, trochanters yellow; femora yellow, tips abruptly black; tibiae brownish yellow, gradually darkened at apices, tarsi passing into black; claws of male small, simple, in *praclauta* with a small tooth. Wings (Fig. 1) chiefly pale yellow, prearcular and costal fields, with the stigma, more saturated yellow; vein *Cu* in cells Cu_1 and *M* narrowly brown; veins brown, *Sc* more yellowed. Venation: Inner end of cell *1st* M_2 acutely pointed; *m* nearly as long as petiole of cell M_1; *m-cu* long, slightly less than distal section of Cu_1.

Abdomen with basal two segments extensively yellowed, borders darkened, outer segments more uniformly dark brown, incisures narrowly yellowed, subterminal segments more uniformly dark brown, hypopygium yellowed. Male hypopygium (Fig. 7) generally as in *praclauta*, including the ninth tergite, ninth sternite and aedeagus. Dististyles, *d*, distinctive, outer style, *od*, short and broad, apex obtuse, the small outer lateral spine short; inner style, *id*, widened at apex, appendage at base of blade a short straight point. The male hypopygium of *praclauta* is shown for comparison (Fig. 8).

Habitat.— Mexico.

Holotype.— ♂, Las Cruces National Park, Mexico D. F., on

Route 15 between Mexico City and Toluca, 3100 meters, July 13, 1966 (O. S. Flint, Jr.); along small stream with shrubby banks in grassy mountain meadow, among stands of *Abies religiosa* and *Pinus montezumae*.

The species is named for Dr. Oliver S. Flint, Jr., specialist on the Trichoptera and other orders of the neuropteroid insects. The most similar species is *Tipula* (*Bellardina*) *praelauta* Alexander, described from Oak Creek Canyon, Arizona, later found near Durango City, Mexico. The distinctive hypopygia of the two species are shown for comparison (Figs. 7 and 8). These flies are very different from all other species of the subgenus in the nature of the wing pattern and may be found to represent a new subgeneric group despite some marked similarities in the hypopygia.

Tipula (*Eumicrotipula*) *estella*, n.sp.

Size medium (wing of female 12.5 mm); antennae with scape and pedicel yellow, flagellum black; mesonotal praescutum yellow with four brown stripes, pleura almost uniformly light gray; legs brownish black to black, femoral bases narrowly yellow; wings with costal cell almost uniformly brown, remainder of wings chiefly yellowed, clouded with pale brown, especially in outer wing cells and in anal field; no trichia in wing cells; R_{1+2} atrophied, cell *1st* M_2 large, M_{3+4} short.

Female.— Length about 11.5 mm; wing 12.5 mm; antenna about 2 mm.

Frontal prolongation of head yellowish gray, including the nasus; palpi brownish black. Antennae with scape and pedicel light yellow, flagellum black, their proximal segments subcylindrical, slightly longer than their verticils, basal enlargements of outer segments more developed. Head very pale brown to yellowish brown, the narrow orbits and the front whitened, occiput light gray; posterior vertex with a narrow brownish black line from summit of the low vertical tubercle to the occiput.

Pronotal scutum gray, vaguely patterned with brown, scutellum clear light yellow, more obscured laterally. Mesonotal praescutum yellow with four brown stripes, intermediate pair confluent on posterior half, anteriorly with a conspicuous blackened central vitta, pseudosutural foveae and a comparable marginal spot darkened; scutum brownish gray, each lobe with two brown spots, central area paler brown; scutellum and mediotergite light gray with a scarcely indicated dark central vitta, parascutella yellow. Pleura and pleurotergite almost uniformly light gray, dorsopleural membrane obscure yellow. Halteres with stem elongate, light yellow, outer half of knob dark brown. Legs with coxae light gray, posterior pair more yellowed, trochanters yellow; remainder of legs brownish black to black, femoral bases yellowed, narrowest on fore pair where about one-sixth of segment is included; no pale subterminal ring as in allied species. Wings (Fig. 2) with costal cell almost uniformly brown, separated from the dark stigma by a whitened spot near outer end

of vein *Sc;* cell *Sc* light yellow with four brown areas that are less extensive than the ground, the first and fourth much smaller; remainder of ground yellowed, extensively clouded with pale brown, more extensive on outer half of wing and in anal cells; veins brown, yellow at arculus and in prearcular field, and in the interspaces of vein *R.* No trichia in wing cells or stigmal region; longitudinal veins beyond general level of origin of *Rs* with trichia, lacking on veins that enclose cell *1st* M_2. Venation: R_{1+2} atrophied; petiole of cell M_1 and *m* subequal; cell *1st* M_2 large, narrowed outwardly; *m-cu* on M_1 shortly beyond origin, M_{3+4} short; *m-cu* only a little shorter than distal section of vein Cu_1; cell *Cu* narrow throughout its length.

Abdomen obscure yellow, patterned with brown, the sternites more evidently so; basal segments, genital shield and valves of ovipositor clearer yellow.

Habitat.— Mexico.

Holotype.— ♀. Lake Zempoala National Park, near Cuernavaca, Morelos, altitude about 10,000 feet, August 10, 1966 (M. E. Smith); in vegetation along shore of shallow lake in upland pine forest.

This species is dedicated to Dr. Marion Estelle Smith, of the entomological faculty of the University of Massachusetts. I am indebted to Dr. Smith for many undescribed species of crane flies from three different biotic regions of the earth, the Nearctic, Neotropical and the Ethiopian. The present fly is the most northerly known record for a species of the *macrotrichiata* group of the subgenus, the only other known Mexican member of the group being *Tipula* (*Eumicrotipula*) *obscuricincta* Alexander, from Chiapas and Guatemala. The latter has the pattern of the wings and legs quite distinct from the present fly which differs further in the venation, as shown. This new species is distinct from all known members of the group by the blackened femora and in the venation. The subgenus *Eumicrotipula* Alexander is the largest in the Neotropical region and has been discussed in some detail in three papers by the writer: *Bull. Mus. Hist. Nat. Paris*, 1922: 74-75; 1922. *Revista de Entomologia*, 17: 172-201; 1946. *Studia Entomologia*, 12: 212-234; 1969.

Limoniinae

Austrolimnophila (*Austrolimnophila*) *subsessilis*, n.sp.

Size medium (wing of female 9 mm); mesonotal praescutum obscure yellow with scarcely differentiated stripes, pleura and pleurotergite clear light yellow; legs brownish yellow to yellow; wings light brown, stigma darker brown, cell M_1 sessile to subsessile.

Female.— Length about 9 mm; wing 9 mm; antenna about 1.2 mm.

Rostrum light yellow; first segment of palpus yellow, remainder brown. Antennae light brown, pedicel more yellowed. Head with front yellowish white, vertex with disk light brown, orbits paler.

Pronotal scutum chiefly yellow, restrictedly patterned with light brown, scutellum light yellow. Mesonotal praescutum obscure yel-

low, the three stripes scarcely differentiated; scutum obscure yellow, each lobe with a pale brown spot near mesal edge; posterior sclerites of notum obscure yellow. Pleura and pleurotergite clear light yellow. Halteres elongate, stem brownish yellow, knob brown. Legs with coxae and trochanters light yellow, remainder of legs brownish yellow to yellow; claws very small. Wings (Fig. 3) light brown, stigma darker brown; a pale brown longitudinal cloud over almost the entire length of cell *R*, broader and more evident beneath *Rs;* veins brown, the trichia relatively short. Venation: *Sc* relatively short, Sc_1 ending nearly opposite fork of *Rs;* R_{1+2} slightly longer than R_2; cell M_1 sessile on one wing of type, very short-petiolate on the other (as figured).

Abdomen with tergites light brown, sternites pale yellow.

HABITAT.— Guatemala.

HOLOTYPE.— ♀, Chicacao, El Naranjo, altitude 3800 feet, August 8, 1949 (T. H. Farr).

The only described generally similar regional species is *Austrolimnophila* (*Austrolimnophila*) *byersiana* Alexander, of Mexico, which differs in the coloration of the legs and wings and in the venation, notably the very long vein R_{1+2} and long petiole of cell M_1.

Shannonomyia semireducta, n.sp.

Wings of female semiatrophied, about one-half the length of body; general coloration of head and thorax brownish gray, praescutal stripes not or scarcely indicated; knobs of halteres small, light brown; legs light to darker brown; wings very pale brown, prearcular and costal fields clear light yellow, stigma scarcely indicated.

FEMALE.— Length about 8.5-9 mm; wing 4.5-4.7 mm; antenna about 1.5-1.6 mm.

Rostrum dark brown, gray pruinose, palpi short, black. Antennae with scape and pedicel dark brown, flagellum black, the segments of latter oval to long-oval, with short verticils. Head brownish gray, unpatterned; anterior vertex broad, about three and one-half times the diameter of scape.

Pronotal scutum dark brownish gray, scutellum yellowish brown. Mesonotal praescutum almost uniformly dark gray or brownish gray; setae of praescutal interspaces sparse, yellow; scutal lobes brownish gray, central area and scutellum light gray, outer posterior angles of lobes and adjoining parts obscure yellow; postnotum light brown, sparsely pruinose. Pleura gray, dorsopleural region more buffy. Halteres with stem yellow, knob small, light brown or brownish yellow. Legs with coxae light brown, sparsely pruinose, trochanters obscure yellow; remainder of legs medium to dark brown, femoral bases restrictedly paler. Wings (Fig. 4) very pale brown, prearcular and costal fields clear light yellow, stigma scarcely indicated; wing base expanded above squama, with a small sclerotized blackened area, prearcular field long; veins very pale brown, yellowed in the brightened fields. Longitudinal veins beyond cord chiefly with trichia, *Rs* usually glabrous, in cases with a few scat-

tered trichia. Venation as shown; Sc_1 and Sc_2 subequal; R_2 beyond radial fork; *m-cu* at near midlength of M_{3+4}.

Abdomen dark brown to blackish brown, the elongate cerci yellowed.

Habitat.— Mexico.

Holotype.— ♀, Las Cruces National Park, Mexico D. F., on Route 15 between Mexico City and Toluca, 3100 meters, July 13, 1966 (O. S. Flint, Jr.); along small stream with shrubby banks in grassy meadow, as discussed further under *Tipula* (*Bellardina*) *flinti*, n.sp. Paratopotypes, 6 ♀ ♀, with type.

The most similar regional species is *Shannonomyia ovaliformis* Alexander, likewise from Mexico, which differs from the present fly chiefly in colorational details. In this species the female remains unknown, the male having the wings of normal size.

Cheilotrichia (*Empeda*) *tanneri*, n.sp.

Mesonotal praescutum and scutum extensively polished black, posterior sclerites of notum paler, pleura yellowed, with a broad brownish black longitudinal stripe; femora conspicuously brownish black to black, bases narrowly yellowed; wings very weakly suffused, prearcular and costal fields light yellow; male hypopygium with dististyles yellow.

Male.— Length about 3-3.3 mm; wing 3.8-4 mm.

Female.— Length about 4.5-4.8 mm; wing 4.4-4.5 mm.

Rostrum and palpi black. Antennae black; proximal flagellar segments short-oval, outer ones more elongate. Head clear light gray; anterior vertex broad.

Prothorax and pretergites yellow. Mesonotal praescutum extensively polished black in front and sublaterally, the latter crossing the suture to include the lateral half of scutal lobe, the extreme margin of praescutum yellow; central areas of posterior praescutum and the scutum more chestnut brown; scutellum chestnut, parascutella light yellow, mediotergite slightly darker brown. Pleura, including dorsopleural region, yellow, with a broad brownish black longitudinal stripe extending from fore coxae to abdomen, slightly paler behind. Halteres yellow. Legs with fore coxae as described, remaining coxae and all trochanters yellow; femora brownish black to black, bases narrowly yellowed, slightly more extensive on posterior pair; tibiae brown to yellowish brown, tips darker brown, more evident on posterior legs; tarsi dark brown to brownish black; legs with abundant relatively short dark setae and further exceedingly small setulae, without scales. Wings (Fig. 5) very weakly suffused, prearcular and costal fields light yellow, including the veins, remaining veins light brown. Venation: Sc_1 ending about opposite one-third to one-fourth *Rs*.

Abdominal tergites dark brown to black, sternites paler brown, more yellowed outwardly, genitalia of both sexes yellow. Male hypopygium (Fig. 9) with both dististyles, *d*, yellow, the inner style a gently curved blade.

HABITAT.— Panama.

HOLOTYPE.— ♂, El Volcan, Chiriqui, altitude 4200 feet, at light, May 25, 1954 (Gordon Field). ALLOTOPOTYPE, ♀, pinned with type. PARATOPOTYPES, 9 ♂ ♀, on five pins, with the types.

I take great pleasure in dedicating this fly to Professor Vasco M. Tanner, as a token of appreciation for his long years of dedicated service to many branches of zoology and as founder and chief supporter of the *Great Basin Naturalist*. The species is readily told from other regional members of the subgenus by the blackened femora and extensively polished black mesonotum.

STUDIES IN NEARCTIC DESERT SAND DUNE ORTHOPTERA[1]

Part XIII. A remarkable new genus and species of giant black Sand treader camel cricket from the San Rafael Desert with key and notes.

Ernest R. Tinkham[2]

One of the rarest and most interesting of the Sand treader camel cricket complex is a large, jet-black creature representing a new genus and species found on certain isolated dunes of the San Rafael Desert, the easternmost of three eremological components of the Great Basin Desert. Very little is known about its habits and less than a dozen specimens have been taken in the past four decades. I have found a few females, unfortunately all dead and dried, lying at the base of small dunes of reddish sand, 19 miles north of Hanksville, Emery County, Utah. Efforts to collect them, in 1970, did not materialize and I look forward to the day when I can study them alive in the field.

The complete fauna of the San Rafael Desert is still inadequately known despite the recent studies of Dr. Wilmer Tanner and associates who have, however, greatly advanced our knowledge of the herpetofauna of this little known desert. Some of the herpetological additions of the past two decades are: the beautiful Golden-headed collared lizard *Crotophytus collaris auriceps* Fitch and Tanner; the Utah chuckawalla *Sauromalus obesus multiforaminatus* Tanner and Avery; the Spotted leopard lizard *Gambelia wislizeni punctatus* Tanner and Banta; the Utah night lizard *Xantusia vigilis utahensis* Tanner, and *Uta stansburiana uniformis* Pack and Tanner just described. Tanner (1958) gave a preliminary list of the herpetofauna which is most imposing and to which many new additions have been made. Among Orthopterans the huge *Trimerotropis agrestis gracewileyae* Tinkham and the black Sand treader, herein described, are only two newly named, but others certainly await discovery. Indications are that the San Rafael Desert will prove to be a most distinctive and interesting eremological component of the Great Basin Desert.

A key to the genera of Sand treaders is here presented to assist the student to correctly diagnose this interesting complex of sand dune Rhaphidophorines and their nearest allies.

Generic Key to the Sand Treader Camel Crickets and Their Allies

1. Mesotibiae with three to five pairs of dorsal spines or spurs (sometimes irregularly placed) exclusive of the calcars 3

[1]Contribution from National Science Foundation Grants 1957-60.
[2]Indio, California

Mesotibiae with two pairs of dorsal spines (sometimes only three) exclusive of the calcars 2

2. Sand basket present and formed by the crowding together apically of four pairs of long aciculate spurs ..... *Rhachocnemis* Caudell

Sand basket absent ..... *Ceuthophilus, Pristoceuthophilus, Udeopsylla, Styracosceles* and *Phrixocnemis*

3. Sand basket formed by four to six pairs of long, moveable, aciculate spurs, somewhat flattened on their inner faces and crowded apically on the caudal tibiae 5

Sand basket absent 4

4. Three caudal tarsomeres, their distoventral angles well-rounded ..... *Daihinia* Haldeman

Four caudal tarsomeres, their distoventral angles strongly acute ..... *Daihinoides* Hebard

5. Size small, external inferior keel of the caudal femora untoothed; caudal tibiae straight. Ovipositor long, slender, about one-half the body length 8

Size medium to very large; external inferior keel of caudal femora toothed; the teeth of variable size, sometimes very large, often smaller and uniform. Ovipositor very short to medium in length 6

6. Color pale; size medium to large. Caudal tibiae straight or curved; the external inferior keel of the caudal femora with either a row of uniform teeth or with irregular, huge, spikelike teeth and smaller teeth. Tarsomere ratio 3-4-3 with the distoventral angles acute. Ovipositor short, equal to the length of the pronotum 7

Color black, size large. Caudal tibiae straight; the external inferior keel of the caudal femora with one to three huge, spikelike teeth widely separated and with several smaller ones. Tarsomere ratio 3-4-3, their distoventral angles lobate. Ovipositor long and slender with six uncinate teeth apically on the lower valvulae; length of ovipositor about half the body length ..... *Utabaenetes* n.g.

7. Size medium-large; caudal tibiae strongly arched in males. External inferior keels of caudal femora with a row of strong uniform teeth ..... *Macrobaenetes* Tinkham

Size medium to very large; caudal tibiae straight in both sexes. External inferior keels of the caudal femora with two to four very large, spikelike teeth centrally situated on the keel, preceded and followed by small and medium teeth ..... *Daihinibaenetes* Tinkham

8. Tarsomere ratio 3-4-4 with their distoventral angles well-rounded ..... *Daihiniella* Hubbell

Tarsomere ratio 3-4-3 with their distoventral angles spined or acute ..... *Ammobaenetes* Hubbell

Utabaenetes Tinkham, n. g.

Utabaenetes is distinguished from all other Sand treader camel crickets by its usually jet-black coloration and by the spination of the legs. The huge spikelike teeth on the inferior external keel of the caudal femora, in the male especially, are reminiscent of *Daihinibaenetes gigantea* Tinkham, but in the new genus these spikes are more widely spaced and are preceded as well as followed by three or four small teeth. The tarsomere ratio is distinct and the spination of distoventral lobes of the first three caudal tarsomeres in *Daihinibaenetes* amply separate it from the *Utabaenetes* where they are lobate in the fore and mesotarsi and plain and nonlobate in the metatarsomeres; a diacritical character of value in separating it from all other members of the Sand treader complex. The black coloration, the sand basket, and the characteristics of the metatarsomeres separate the new genus from *Daihinia* and *Daihiniodes*. From the black *Udeopsylla robusta* of the Great Plains which it resembles so closely and to which evident relationship would be expected, the sand basket, the lack of many pairs of ventral spines or spurs on the caudal tibiae, and the tarsomere ratio of 3-4-3 and not 3-4-4 dispel any idea of close relationship. Even the ovipositors, although superficially alike, are when studied quite dissimilar. The curved caudal tibiae and the row of medium-sized and uniform teeth on the external inferior keels of the caudal femora in *Macrobaenetes* quickly separated that genus from the black *Utabaenetes* herein described.

Description.— Body large and heavy and form typical of the Rhaphidophorinae. Fore and middle legs average; hind legs of rather heavy build. The chief diacritical features lie in the spination of the legs. Forelegs in both male and female bearing a strong toothlike projection on the vertical foremargin of the forecoxae; fore femora unspined dorsally; ventrally with one to several minute teeth on the external keel and six to eight or more on internal keel with usually a large subapical spine in the male. Dentition reduced in the female on the external inferior keel and with only the large subapical spine present on the inferior internal keel. Foretibiae unspined dorsally in both sexes except for the apical calcars, the external of which is much the largest and aciculate; ventrally there are four pairs of large acuminate spurs plus long apical calcars. Middle legs without coxal spurs; mesofemora unspined dorsally; ventrally both keels with four to ten teeth in the male, number much reduced in the female. Mesotibiae dorsally with four, sometimes four and one-half, pairs of long acuminate spurs plus apical calcars in both sexes; ventrally with three to four pairs of smaller spurs mostly in the apical half plus a very large pair of acuminate calcars. Mesotarsomeres four,

the distoventral angles of each somewhat weakly lobate. Hindlegs with usually two, sometimes three or four very large spikelike teeth plus one or two small apical teeth on the external inferior keel of the femora in the male; these much reduced in the female. Internal inferior keel of caudal femora in the male with a few small widely spaced teeth; keel entire in female. Caudal tibiae unspined ventrally in both sexes except for one or two small median subapical teeth and a large pair of apical calcars. Dorsal surface of the caudal femora with eight pairs of long aciculate spurs plus the apical calcars in both sexes, five pairs of which are crowded into the apical quarter to form the sand basket, the additional spurs on outer and inner dorsal keels in the basal portions unpaired with one to four minute teeth in the interspaces. Caudal tarsomeres three, the distoventral angle of the first two normal, of segment 3 somewhat acute, this character distinguishing *Utabaenetes* from all the other genera.

Male genitalia with supra-anal plate roundly triangular and strongly deflexed (may be due to preservation in alcohol); cerci very long and sparsely hirsute; subgenital plate with long forcipate arms. Female genitalia with circular supra-anal plate; ovipositor straight with slight recurvature and longer than the pronotum. Dorsal valvulae terminating in an acute spine; ventral valvulae with six uncinate hooks, four of which are crowded apically.

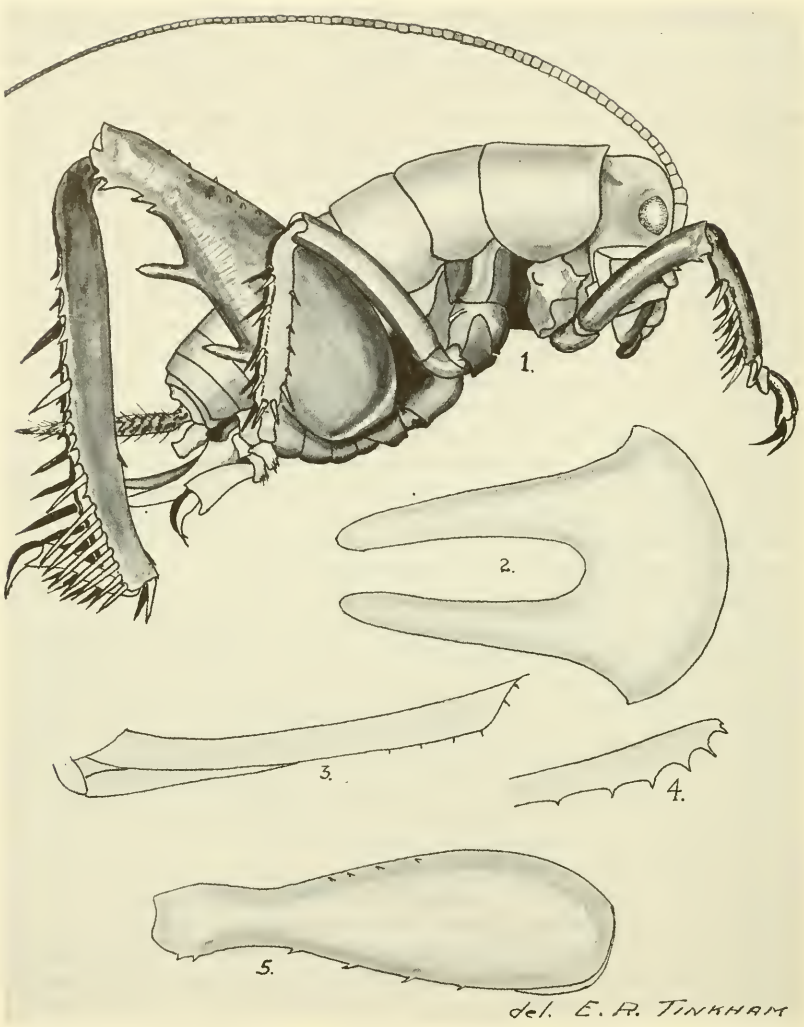
TYPE-SPECIES.— *Utabaenetes tanneri*, new species.

This monotypic new genus and species is named to honor Dr. Vasco M. Tanner and his long, illustrious career as editor and scientist. Dr. Tanner retires in December 1970 as editor of the *Great Basin Naturalist* after 30 years of devoted and meritorious services. During that time he has developed that publication into a highly respected and first-class scientific journal. During 45 years of outstanding leadership at Brigham Young University—38 of those years as the chairman of the Department of Zoology and Entomology—he has developed that department into a widely recognized institution and has shaped the lives of numerous younger scientists who have been fortunate enough to study under his kindly tutelage. In the field of entomology he has become a well-known authority on the Curculionidae and Tenebrionidae. In the zoological realm he has published papers on the fish, amphibians, and reptiles, particularly of the Great Basin Desert.

Utabaenetes tanneri, n. sp.

DESCRIPTION.— Male: body jet black, form large and typical of this group of the Rhaphidophorinae. Head almost as broad as deep; fore margin of the pronotum very slightly emarginated; palpi with terminal segments bulbous.

Leg spination as follows: fore legs with the vertical coxal margin bearing a large toothlike projection; forefemora unarmed dorsally, ventrally with the external inferior keel bearing four to five small teeth, the internal keel with four to five very minute teeth plus a larger subapical tooth. Foretibiae unspined dorsally, ventrally with



Figs. 1-5. *Utahaenetes tanneri* Tinkham: 1. Male holotype enlarged six times and reduced one-half; 2. Ventral view of subgenital plate of male paratype; 3, Ovipositor of female allotype; 4, Apical view of ventral valvulae of female allotype; 5, External view of right caudal femora of female allotype.

three to four pairs of long tapering spurs plus the apical calcars, those externally twice the size of the internal ones. Foretarsi short, the first two segments extremely short, the third three times the combined length of 1 and 2; and distoventral angles of all three lobate. Middle legs with mesocoxal carinae unarmed; mesofemora unspined dorsally; ventrally with three to four teeth on each keel and sometimes a tooth on the lower genicular lobes. Mesotibiae with

four pairs of long, tapering acute spurs dorsally plus similar apical calcars; ventrally with three pairs of much smaller acuminate spurs plus a very large pair of apical calcars. Mesotarsi 4-segmented, the first three segments equal in length to the fourth; tarsomeres 2 and 3 very short; the distoventral angles of 2 and 3 quite lobate, of 1 angular and of 4 acutely lobate. Hind legs rather heavy with caudal femora dorsally with a row of widely spaced minute teeth on the internal dorsal ridge plus other scattered teeth nearby; ventrally with the external inferior keel bearing one to two hugh spikelike teeth in the apical half plus much smaller teeth basad and apicad of these and with twin teeth on the basal portions of the genicular lobes; internal inferior keel with five to seven small teeth scattered along its length plus a larger twin pair on the base of the genicular lobe. Caudal tibiae dorsally with one to three small, median, subapical appressed teeth plus a pair of calcars; ventrally with eight pairs of long aciculate spurs, six pairs of which are crowded into the apical third to form the sand basket. External inferior keel with spur 1 in the basal third preceded by three to four small teeth, spur 2 separated from spur 1 by four to five small teeth; spur 2 separated from the six spurs of the sand basket by one small tooth. Internal inferior keel with spur 1 in the basal quarter preceded by one to two small teeth and with three small teeth between spurs 1 and 2 which is medianly placed with one small tooth separating spur 2 from the rest of the sand basket. Caudal tarsi 3-segmented, segments 1 and 3 equal in length, segment 2 very short; the distroventral angles in all three barely lobate, a distinctive feature of *Utabaenetes*.

Genitalia with supra-anal plate triangular with broadly rounded apex which is strongly deflexed; cerci long and tapering, sparsely hirsute. Pseudosclerite broadly triangular, the ventral surface deeply excavate, the dorsal surface flat with strongly reflexed semicircular apical lip. Subgenital plate large with very long forcipate arms.

Female.— Closely similar to the holotype in size. Leg spination as follows: procoxal spine smaller; forefemora untoothed dorsally; ventrally as in the male. Foretibiae as in the male except that the internal inferior keel has one additional small spine. Foretarsi as in the male. Middle legs as in the holotype. Hind legs with caudal femora dorsally as in the male; ventrally with the dentition on the external inferior keel greatly reduced in size with five widely spaced small teeth in the apical two-thirds plus twin pairs of small teeth on the basal portions of the genicular lobes; internal inferior keel untoothed except for one to two teeth on the lower genicular lobes. Caudal tibiae and tarsi as in the holotype.

Genitalia with the supra-anal plate small and circular in outline with bevelled margin and central basal depression. Cerci long, tapering, hirsute. Subgenital plate, shallowly transverse with the margin gently convex. Ovipositor long, about half the body length; dorsal valvulae terminating in an acute apex; ventral valvulae with six uncinate hooks, four of which are crowded apically.

Type Material.— Male holotype: Hanksville, Wayne County, San Rafael Desert, April 20, 1928, W. J. Gertsch. Calliper measure-

ments in millimeters: body length 18.5; pronotum 4.9; caudal femora 15.6x4.0; caudal tibiae 12.5. Holotype deposited in the Museum of Zoology of the University of Michigan.

Female allotype: Calliper measurements in millimeters; body length 18.6, pronotum 5.3, caudal femora 14.8, caudal tibiae 11.2; ovipositor 11.8. Female allotype deposited in the Museum of Zoology, University of Michigan.

Male paratypes: Two with same data as holotype. One from Willow Springs, Escalante Desert, Kane County, Utah, June 1936, Department of Entomology, Brigham Young University. Measurements in millimeters: body length 17.9-20.5; pronotum 4.8-5.2; caudal femora 15.1-16.1; caudal tibiae 12.5-15.1. Male paratypes deposited in the Tinkham Eremological Collection and the Department of Entomology of Brigham Young University.

Paratypes from the holotype locality are closely similar to holotype in every respect although one male is tan in coloration and may be somewhat teneral. The Willow Tank male paratype has the dentition on the external and internal inferior keels more numerous on all femora. Dentition on all tibiae quite similar to the holotype.

Female paratypes: one with same data as the allotype. Three collected dead and dried at base of small pale-reddish dunes, 19 miles north of Hanksville, Aug. 8, 1958, Ernest R. Tinkham. Calliper measurements in millimeters: body length 17.0-18.5; pronotum 4.8-5.2; caudal femora 13.9-14.8; caudal tibiae 10.7-11.5; ovipositor 10.8-11.7. Female paratypes deposited in the Tinkham Eremological Collection and the Department of Entomology at Brigham Young University.

Female paratypes similar to the allotype in every respect.

Biology: nothing is known about these. It is not known whether the nymphs are pale tan in coloration, becoming black after maturation and exposure to increasing heat as the temperature increases in the spring. In a conversation with Dr. Willis J. Gertsch, authority on spiders, on September 13, 1970, at his home in Portal, Arizona, I was informed that one pair were mating about midnight of April 20, 1928, but after the lapse of 42 years no particulars were remembered. Efforts to find the creature in late July 1970 did not materialize. The lateness and dryness of the season are suspected to have been the reason to find no living material.

Orthopteran associates: In 1958, the author found the only Orthopteran associates on the Hanksville dunes, 19 miles north of Hanksville, were the huge *Trimerotropis agrestis gracewileyae* Tinkham, the rare *Trimerotropis salina*, and at night the handsome *Plagiostira gilletti* and an undescribed species of *Ammobaenetes*.

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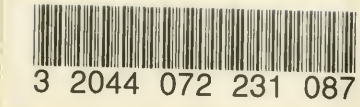
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